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BENTHIC MACRO- AND MEIOFAUNA IN THE GULF OF BOTHNIA (NORTHERN BALTIC)

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ABSTRACT

As part of the Baltic Marine Biologists' "Joint macro- and meiofauna sampling programme for the whole Baltic", 70 stations in the Gulf of Bothnia were visited and sampled for macro- and/or meiofauna.

Results confirm the extreme poverty of macrofauna in the Bothnian Bay as compared to the Bothnian Sea, and especially the well oxygenated parts of the Baltic proper. The meiofauna is not as strongly reduced in the Bothnian Bay, but still less abundant than in the Bothnian Sea. Several meiofauna groups of great importance in the rest of the Baltic seem to have their limit of distribution in the southernmost Bothnian Bay.

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INTRODUCTION

After one of the lectures given at the Third Baltic Symposium on Marine Biology in Helsinki, June 1973, a discussion ensued concerning the relative importance of benthic macro- and meiofauna in the Baltic and their respective suitability for monitoring purposes. Out of this discussion grew the idea of the "Joint macro- and meiofauna sampling programme for the whole Baltic", an international, cooperative investigation, which would give us a first rough quantitative survey of the meiofauna and at the same time the first directly comparable macrofauna results from the entire Baltic area. The detailed plans for the investigation were worked out by Elmgren and Rosenberg after consultation by correspondence with other interested parties within the macro- and meiofauna working groups of the Baltic Marine Biologists. Elmgren has since acted as coordinator of the programme. The original plan was to undertake the sampling during 1974 and present the results during the Fourth Baltic Symposium on Marine Biology in Gdansk, October 1975. The sampling in 1974 was, however, less successful than hoped for and the sampling phase of the programme was therefore extended. This report will therefore only give results from the Gulf of Bothnia. It is planned to publish elsewhere the raw data from the whole programme after its completion. Macrofauna samples were examined by Andersin, Evans, Kangas, Lassig, Leppäkoski and Rosenberg, meiofauna by Elmgren, Evans and Varmo.

INVESTIGATION AREA

The Gulf of Bothnia (Fig. 1) can be divided into several subareas and in this study the Bothnian Sea, including the Åland Sea and the Archipelago Sea, will be considered to lie between 59°40'N and 63°30'N and west of 23°E, and the Bothnian Bay north of 63°30'N. Both areas are fairly shallow (Table 1), with maximum depths of 126 m in the Bothnian Bay and 301 m in the northern Åland Sea. They are both brackish in character, with stable salinities of about 5 ‰ at the surface and 6—7 ‰ at the bottom of the Bothnian Sea, and salinities of about 3 ‰ at the surface and 4 ‰ at the bottom of the Bothnian Bay. Unlike the Baltic Proper, the Gulf of Bothnia has high oxygen levels in its bottom waters. The hydrography of the area has been described by Fonselius (1971) and Dahlin (1977) and the biology of the area by Segerstråle (1957) and Haahtela (1974, the Bothnian Bay only). The Bothnian Bay, especially, has an almost arctic character, with ice for about half the year in its northernmost part (see Haahtela 1974).

MATERIALS AND METHODS

Sampling stations were selected by means of stratified random sampling. Four strata were used in the Gulf of Bothnia (Table 1). The geographical extent of the strata has been taken from a bathymetric chart of the Baltic, published by the Swedish Navy (Djupskiktskarta, scale 1:1 000 000, Generalstabens Litografiska Anstalt, Stockholm 1971). It is well known that abundance, biomass, diversity and variability of at least the macrofauna is greater in shallower water in most of the Baltic, hence the greater sampling effort in this depth zone.

Weighted means and their standard errors were calculated according to Snedecor and Cochran (1967:520—521). It should be noted that the depth strata are represented by samples from the area which on the chart used for stratification are given as of that depth. Since the chart is not exact, a few stations fall outside the nominal depth range of the stratum, but are included in its results.

At each station one sample each of macrofauna, meiofauna and sediment was taken, when bottom type permitted. Macrofauna was sampled with a 0.1 m² van Veen grab and sieved through a 1 mm sieve. The sieve residue was preserved in formaldehyde solution buffered with hexamethylene tetramine. Biomass was determined at least one month after preservation as formalin wet weight, after blotting on filter paper (mussels with shells opened). Mysids were excluded

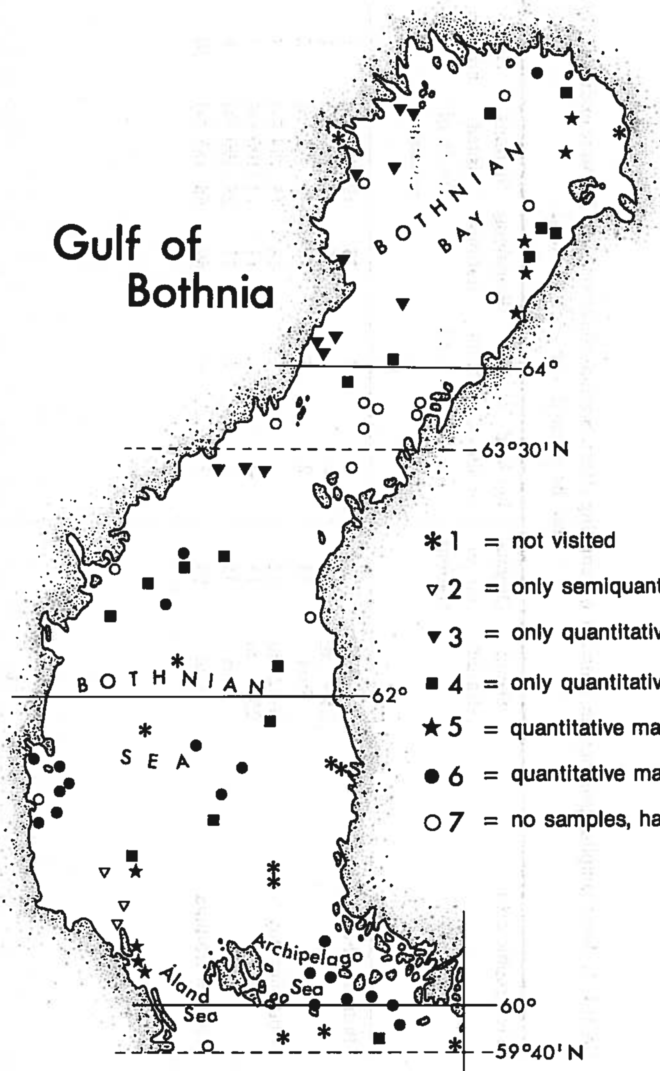

Fig. 1. Map showing sampling area with subdivisions and sampling success at all sampling stations deeper than 5 m. Explanation of numbered symbols as follows:

✱ 1 = not visited
▽ 2 = only semiquantitative meiofauna
▼ 3 = only quantitative meiofauna
■ 4 = only quantitative macrofauna
★ 5 = quantitative macrofauna & semiqauantitative meiofauna
● 6 = quantitative macro- & meiofauna
○ 7 = no samples, hard bottom of too shallow

TABLE 1. Joint sampling programme, sampling strata in the Gulf of Bothnia.

Geographic area	Depth stratum (from chart)	Estimated area km^2	Original no. of stations	Stations per 1000 km^2
Bothnian Sea	0—25 m	27 889	28	1.0
	25+ m	52 207	26	0.5
	Sum	80 096	54	
Bothnian Bay	0—25 m	14 826	22	1.5
	25+ m	17 745	13	0.73
	Sum	32 571	35	
Gulf of Bothnia	Total	112 667	89	0.79

TABLE 2. Joint sampling programme, outcome of sampling effort. Stations shallower than 5 m were excluded from the investigation, since they could not be reached with all boats used.

Geographic area	Depth stratum	Original no. of stations	On land or similar	Too shallow (<5 m)	Remaining stations	Stations visited () = % of remaining	Hard bottom	Sampling success Macrofauna samples	Sampling Meiofauna quantitative samples	Success Meiofauna semi-quantitive samples
Bothnian Sea	0—25 m	28	2	3	23	19 (83 %)	1	16	11	(+4)
	25+ m	26	—	—	26	21 (81 %)	1	16	11	(+3)
	Sum	54	2	3	49	40 (82 %)	2	32	22	(+7)
Bothnian Bay	0—25 m	22	1	3	18	15 (84 %)	3	9	5	(+5)
	25+ m	13	—	—	13	13 (100 %)	5	4	4	
	Sum	35	1	3	31	28 (90 %)	8	13	9	(+5)
Gulf of Bothnia	Total	89	3	6	80	68 (85 %)	10	45	31	(+12)

from the macrofauna as they are not truly benthic animals. Meiofauna was sampled with a small gravity corer (sampling area 3.9 cm^2, weight 3 kg, wall thickness of stainless steel coring tube 0.4 mm), a number of which were specially manufactured for this investigation (description in Ankar and Elmgren 1976). A few samples were taken as subsamples from the van Veen grab, when no cores were obtained. These are considered as semi-quantitative only and were not used in the quantitative calculations. Whole cores, in most cases longer than 5 cm, were preserved in formaldehyde solution, buffered as above, and with Rose Bengal added to stain the meiofauna. The animals were separated from the sediment by sieving through a 1 mm sieve (to remove macrofauna) followed by fourfold decantation (in a 250 ml measuring cylinder of 20 cm water depth, settling time 60 s before decantation) and sieving of the supernatant water through 200, 100 and 40 μm, and of the heavy residue through the 200 μm and 100 μm sieves (the 40 μm heavy residue was discarded, since it was found to contain very few animals). The number of animals found in each fraction was noted, and used in computing biomasses. For 16 samples from the Bothnian Sea and 8 from the Bothnian Bay, subsamples of the nematodes and almost all other animals were measured for accurate biomass calculations, by length-weight regression equations or by conversion of calculated volume into wet weight. The mean weights thus found for each group in each fraction were used for calculating the biomass in the remaining samples.

Sampling was performed during April—August 1974 and June 1975 in the Bothnian Sea, and during July—September 1974 in the Bothnian Bay.

RESULTS

SAMPLING COVERAGE

The success of the sampling effort is shown in Table 2 and the map (Fig. 1). A high proportion of the stations were visited. In the Bothnian Bay, however, many stations had bottoms too hard for sampling and sampling difficulties meant that no macrofauna samples were obtained on the Swedish side and little meiofauna along the Finnish coast. The final outcome is therefore better in the Bothnian Sea, where fewer stations had hard bottoms, but here unfortunately some of the meiofauna cores were treated differently and can only be regarded as semiquantitative.

MACROFAUNA

The macrofauna shows decreasing diversity, measured as number of taxa per grab sample, from the Archipelago Sea in the south to the Bothnian Bay in the north, but with a possible small increase in the northernmost samples (Fig. 2). (Oligochaeta, chironomid larvae and Hydrobiidae were counted as single taxa).

Macrofauna abundance (Fig. 3) also decreases, from a mean of several thousand per square meter in the south, to a few hundred in the Bothnian Bay, while the biomass (Fig. 5) decreases even more drastically, from a mean of around 100 $g \cdot m^{-2}$ in the south, to less than 1 $g \cdot m^{-2}$ in the Bothnian Bay. An important difference between the Bothnian Bay and the rest of the Gulf of Bothnia can be seen in the correlation of biomass to depth (Fig. 7). In the Bothnian Sea macrofauna biomass decreases radically with depth, whereas in the Bothnian Bay no such tendency is evident, in fact, the highest value is the deepest.

The bivalves *Macoma balthica* (L.) and *Mytilus edulis* L. totally dominate the biomass in the 0—25 m stratum of the Bothnian Sea, whereas they are of little importance in the deeper stratum and entirely absent from our samples from the Bothnian Bay (Table 3). In the deeper parts of the Bothnian Sea, the crustaceans *Pontoporeia affinis* Lindström and *Mesidotea entomon* (L.) are totally dominant; and the same is true for *P. affinis* in both depth strata of the Bothnian Bay, even though its abundance and biomass is much lower than in the Bothnian Sea. The only other animal contributing more than 1 g $\cdot$ m^{-2} in any stratum is the priapulid worm *Halicryptus spinulosus* v. Siebold in the shallow stratum of the Bothnian Sea.

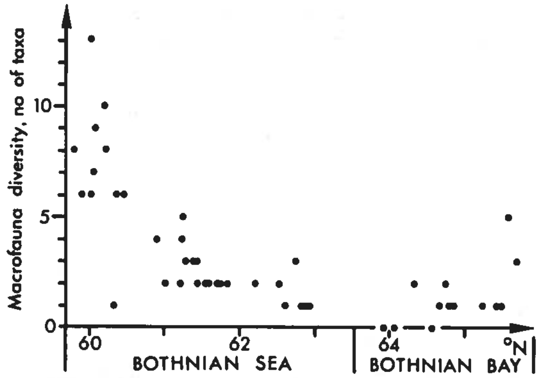

Fig. 2. Macrofauna diversity at random stations from south to north in the Gulf of Bothnia, measured as a number of taxa per 0.1 m² van Veen grab sample.

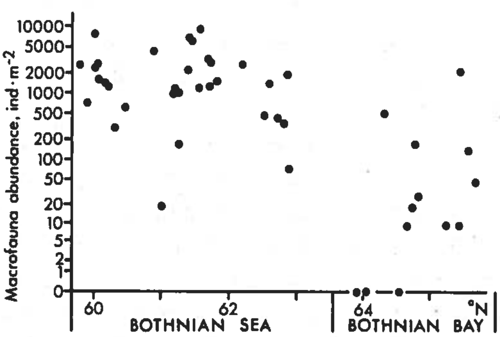

Fig. 3. Macrofauna abundance at random stations from south to north in the Gulf of Bothnia, recalculated as ind $\cdot$ m^{-2} (one 0.1 m² van Veen grab sample per station).

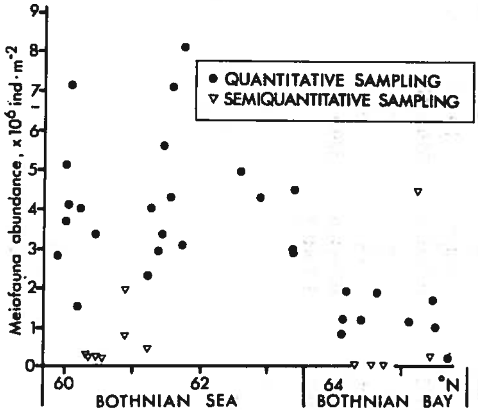

Fig. 4. Meiofauna abundance at random stations from south to north in the Gulf of Bothnia, recalculated as ind · m^{-2} (one 3.9 cm^2 gravity core sample per station). Triangles in the Bothnian Sea represent differently treated and hence semi-quantitative core samples. Triangles in the Bothnian Bay represent 3.9 m^2 subsamples from the van Veen grab.

MEIOFAUNA

The meiofauna abundance (Fig. 4) shows a decline from south to north similar to that of the macrofauna, which is perhaps less steep, but even more clearcut. All but one of 22 fully quantitative samples from the Bothnian Sea are above 2×10^6 ind $\cdot$m^{-2}, while all 9 from the Bothnian Bay are below that value. The meiofauna biomass (Fig. 6) also shows a clear decrease from south to north, but much smaller than for the macrofauna. In clear contrast to the macrofauna, the meiofauna biomass shows no discernible correlation with depth (Fig. 8). Weighted means of abundance and biomass of the meiofauna and its main component groups are given in Table 4. (The 0—25 m and 25+ m depth strata are not given separately, since they do not differ much). The differences between the Bothnian Sea and the Bothnian Bay are clear, but more moderate than for the macrofauna. The temporary meiofauna (mostly juvenile *Pontoporeia affinis*, but including Hydrobiidae, bivalves, polychaetes, *Halicryptus* and chironomid larvae) constituted about one third of the meiofauna biomass in the Bothnian Sea, but with the drastic decline of the macrofauna in the Bothnian Bay, it all but disappeared. The kinorhynchs also lose all importance in the Bothnian Bay, while the ostracods decline greatly in biomass, but still remain relatively important. Only two groups, the Acari (almost entirely Halacaridae) and the harpacticoids (including the nauplii, which are almost all harpacticoid nauplii) show increased abundance and biomass in the Bothnian Bay.

For all meiofauna samples pooled, the fraction of the abundance found in the different sieves was: 200 μm: 6 %, 100 μm: 28 % and 40 μm: 66 % and for the biomass 200 μm: 81 %, 100 μm: 15 % and 40 μm: 4 %.

TABLE 3. Joint sampling programme, macrofauna. Biomass distribution of the dominant taxa in the four sampling strata and weighted means of abundance and biomass for the whole bottom areas of the Bothnian Sea and Bothnian Bay, that can be sampled with the gear used. Figures after ± denote standard error of mean.

TAXON	BOTHNIAN SEA Biomass (formalin wet weight) g m^{-2}			BOTHNIAN SEA Abundance ind. m^{-2}	BOTHNIAN BAY Biomass (formalin wet weight) g m^{-2}			BOTHNIAN BAY Abundance ind. m^{-2}
	Depth stratum 0—25 m	Depth stratum 25+ m	Weighted mean	Weighted mean	Depth stratum 0—25 m	Depth stratum 25+ m	Weighted mean	Weighted mean
Halicryptus spinulosus	1.9	—	0.6 ± 0.3	8 ± 3	—	—	—	—
Mesidotea entomon	1.1	6.1	4.5 ± 1.8	16 ± 10	<0.1	—	<0.1	1 ± 1
Pontoporeia affinis	3.1	10.5	8.1 ± 1.7	1874 ± 444	0.2	1.2	0.7 ± 0.6	316 ± 274
Macoma balthica	100.2	0.3	32.3 ± 6.4	145 ± 31	—	—	—	—
Mytilus edulis	49	<0.1	15.7 ± 13.8	67 ± 53	—	—	—	—
TOTAL MACROFAUNA	162.5	17	62.7 ± 18.8	2242 ± 462	0.2	1.2	0.7 ± 0.6	326 ± 274
No of taxa per grab	5.9	2.1	3.4 ± 0.4		1.8	0.5	1.1 ± 0.3	

TABLE 4. Joint sampling programme, meiofauna. Weighted means. ± denotes standard errors of means.

TAXON	BOTHNIAN SEA				BOTHNIAN BAY			
	Abundance		Biomass	(wet weight)	Abundance		Biomass	(wet weight)
	10^3 ind m^{-2}	%	g m^{-2}	%	10^3 ind m^{-2}	%	g m^{-2}	%
Turbellaria	45 ± 10	1	0.4 ± 0.1	6	15 ± 4	1	0.2 ± 0.1	11
Nematoda	3855 ± 335	89	0.7 ± 0.1	11	867 ± 121	72	0.3 ± 0.1	14
Kinorhyncha	76 ± 18	2	0.1 ± 0.1	2	2 ± 2	< 1	< 0.1	< 1
Oligochaeta	3 ± 1	4	0.3 ± 0.2	4	5 ± 2	< 1	0.2 ± 0.1	9
Copepod nauplii	112 ± 22	3	< 0.1	< 1	113 ± 58	9	< 0.1	2
Harpacticoida, cop. & ad.	90 ± 18	2	0.4 ± 0.1	6	124 ± 54	10	0.4 ± 0.2	24
Ostracoda	57 ± 10	1	2.1 ± 0.4	32	14 ± 8	1	0.3 ± 0.2	18
Pontoporeia affinis, juv.	4 ± 2	< 1	2.1 ± 1.1	32	—	—	—	—
Acari	19 ± 7	< 1	< 0.1	< 1	38 ± 11	3	0.1 ± 0.1	5
Others	51	1	0.4	6	29	2	0.3	15
TOTAL	4312 ± 384	100	6.5 ± 1.4	100	1207 ± 183	100	1.8 ± 0.4	100
Temporary meiofauna	10 ± 2	< 1	2.3 ± 1.1	35	1 ± 1	< 1	< 0.1	2
Permanent meiofauna	4302 ± 384	> 99	4.2 ± 0.5	65	1206 ± 183	> 99	1.8 ± 0.5	98

MACROFAUNA-MEIOFAUNA RELATIONSHIP

The relationship between macro- and meiofauna biomass at all stations where quantitative samples of both types were obtained is shown in Fig. 9. No clear interdependence can be discerned, which is perhaps surprising as the meiofauna also contains the young stages of the macrofauna. The macrofauna shows a wider range of variation in both abundance and biomass than the meiofauna. This variation is greater both with depth (Figs. 7 and 8) and between geographical regions (Figs. 3, 4, 5, 6) as well as within the same geographical area and depth zone (Figs. 7 and 8). For the Bothnian Sea the ratio of macro- to meiofauna biomass, based on the weighted means, is about 10 and for the Bothnian Bay about 0.4.

DISCUSSION

The small number of stations and samples involved in this synoptic survey obviously means that only striking differences between geographic regions and depth zones can be demonstrated. Thus the limited number of samples within each geographic area has not made it possible to demonstrate clearly the influence of sediment type on the benthic communities, even though this has been achieved by similar sampling approaches by O'Connor (1972), Parker (1975) and Ankar and Elmgren (1975, 1976).

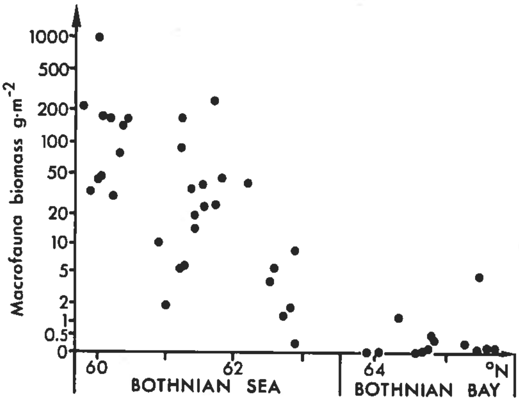

Fig. 5. Macrofauna biomass at random stations from south to north in the Gulf of Bothnia, recalculated as g · m^{-2} formalin wet weight (one 0.1 m² van Veen grab sample per station).

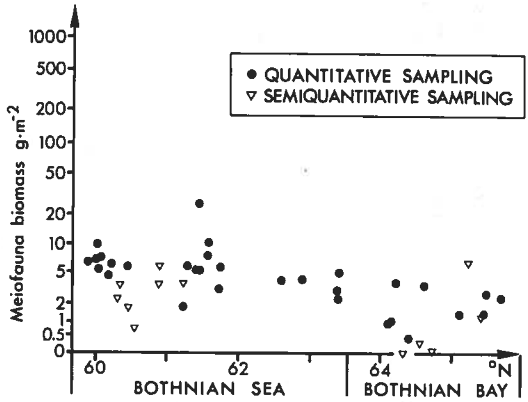

Fig. 6. Meiofauna biomass at random station from south to north in the Gulf of Bothnia, recalculated as g · m^{-2} wet weight (one 3.9 cm² gravity core sample per station). Triangles in the Bothnian Sea represent differently treated and hence semi-quantitative core samples. Triangles in the Bothnian Bay represent 3.9 cm² subsamples from the van Veen grab.

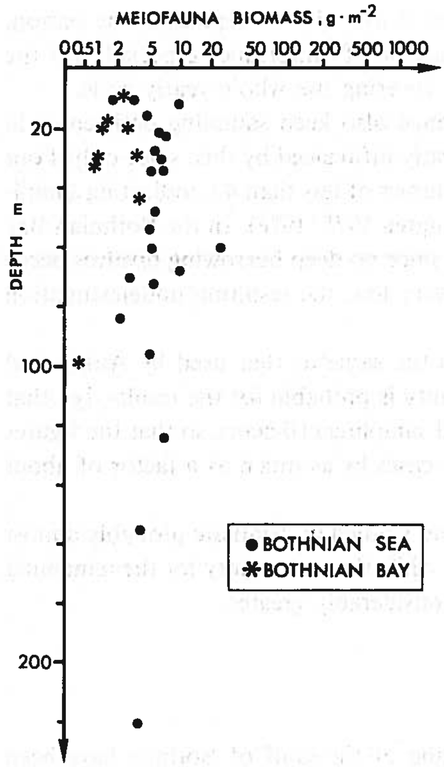

Fig. 7. Macrofauna biomass versus depth at random stations in the Gulf of Bothnia, recalculated as g · m^{-2} formalin wet weight (one 0.1 m² van Veen grab sample per station).

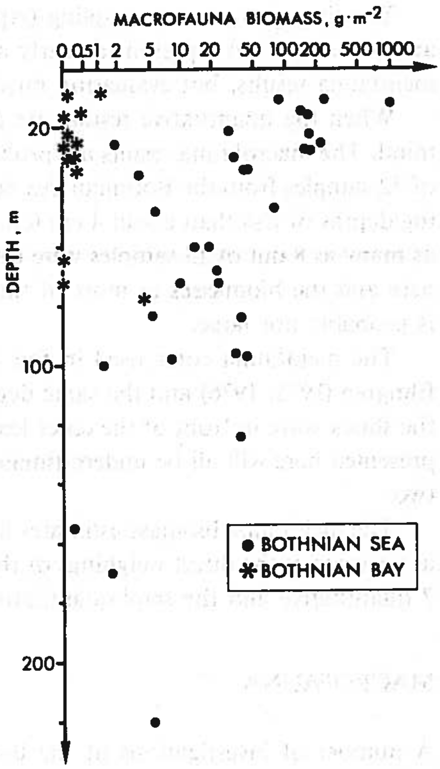

Fig. 8. Meiofauna biomass versus depth at random stations in the Gulf of Bothnia, recalculated as g · m^{-2} wet weight (one 3.9 cm² gravity core sample per station). Semiquantitative samples omitted.

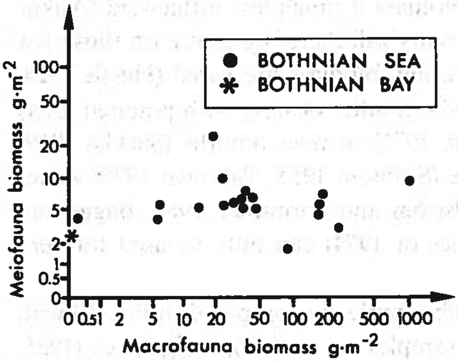

Fig. 9. Relationship between macrofauna biomass (formalin wet weight) and meiofauna biomass (wet weight), both recalculated as g · m^{-2}, at all random stations in the Gulf of Bothnia where samples of both types were obtained. Semi-quantitative samples omitted.

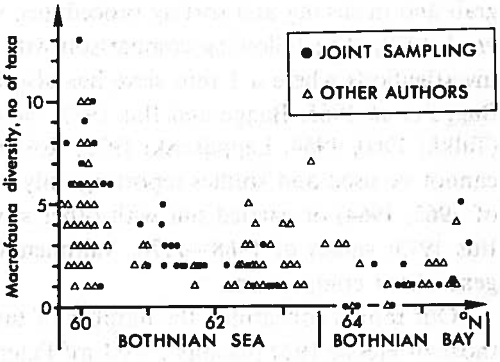

Fig. 10. Macrofauna diversity from south to north in the Gulf of Bothnia, measured as number of taxa per station (see text for further details).

The timespan of our sampling (April—September) is too wide to represent one season, and too narrow to represent a yearly average. This may be of importance especially for the meiofauna results, but evaluation must await studies covering the whole yearly cycle.

When the quantitative results are discussed, we must also keep sampling deficiences in mind. The macrofauna results are probably not so greatly influenced by this, since only 4 out of 32 samples from the Bothnian Sea had sampling volumes of less than 4 l, indicating sampling depths of less than about 4 cm (cf. Ankar and Elmgren 1975, 1976). In the Bothnian Bay as many as 8 out of 13 samples were less than 4 l, but since no deep burrowing bivalves occur here and the biomasses in most of these samples is very low, the resulting underestimation is probably not large.

The meiofauna corer used in this investigation is the same as that used by Ankar and Elmgren (1975, 1976) and the same degree of uncertainty is probable for the results, i.e., that the shock wave in front of the corer leads to a reduced sampling efficiency so that the figures presented here will all be underestimates, in the worst cases by as much as a factor of about two.

The meiofauna biomass estimates for the 24 samples studied in detail are probably almost as accurate as the direct weighings of the macrofauna, while the uncertainty for the remaining 7 quantitative and the semi-quantitative samples is considerably greater.

MACROFAUNA

A number of investigations of the benthic macrofauna of the Gulf of Bothnia have been published, but quantitative comparisons can be meaningfully made only with those that have also used a 1 mm sieve. A recent intercalibration has shown that even when the same grab type and sieve size are used, abundance values may differ by as much as a factor of two even between highly experienced investigators, due to small differences in the construction of the grab and in sieving and sorting procedures, whereas biomass is much less influenced (Ankar *et al.* 1979). The following comparison with earlier results will therefore centre on those few investigations where a 1 mm sieve has also been used, and biomass measured (Hessle 1924, Bagge *et al.* 1965, Bagge and Ilus 1973: values of 1967). Studies dealing with polluted areas (Tulkki 1960, 1964, Leppäkoski 1975, Rosenberg *et al.* 1975) or river mouths (Särkkä 1969) cannot be used and studies reporting only abundance (Sjöblom 1955, Valtonen 1976: values of 1962, 1964) or carried out with other sieves (Dahlström and Sormunen 1965, Bagge and Ilus 1973: values of 1968—1970, Valtonen 1976: values of 1974) can only be used for very generalized comparisons.

Our results concerning the number of taxa per grab sample are compared in Fig. 10 with those of Hessle 1924 (usually 2×0.1 m^2 Petersen grab samples per station), Bagge *et al.* (1965: Ekman or van Veen grabs, normally 0.06—0.17 m^2 per station) and Bagge and Ilus (1973: values of 1976, 0.115 m^2 van Veen, 1—2 hauls per station). Their results agree well with ours.

In Fig. 11 our biomass results are compared with those of Bagge et al. (1965) and Bagge and Ilus (1973: values of 1967). Here too, agreement is quite good. Hessle's (1924) results are generally slightly higher than ours and those of Bagge and Ilus (1973) in the Bothnian Bay, but distinctly lower in the Bothnian Sea, and were not included in Fig. 11. From Hessle's mean biomasses for the different depth zones in the various parts of the Gulf of Bothnia and the depth distribution values in Olsson (1971), we can calculate rough mean values of about 2.5 $g \cdot m^{-2}$ formalin wet weight for the Bothnian Bay and about 16 $g \cdot m^{-2}$ for the Bothnian Sea (including the Åland Sea). His higher values in the Bothnian Bay are from an area along the Swedish coast and largely within its archipelagos, where no macrofauna samples were obtained in our programme. Our weighted mean values for the Bothnian Bay might have been higher if this area had been sampled. His decidedly lower values for the Bothnian Sea may be influenced by differences in method, but may also indicate a gradual general eutrophication of this part of the Baltic over the last 50 years.

A more superficial comparison with the results of those authors who only report abundance or used other sieves (references given earlier) also tends to show that the macrofauna results of the "Joint sampling programme" have confirmed and in some ways complemented the picture of the quantitative macrofauna distribution in the Gulf of Bothnia first drawn by Hessle (1924), and since added to by a number of authors. The main reservation concerns biomass levels in the Bothnian Bay, which may have been somewhat underestimated because of lack of samples and the absence from our few samples of large *Mesidotea* specimens, a few of which could have made a considerable difference to the weighted mean (cf. Valtonen 1976: values of 1974). Haahtela (1975) has shown that, while generally sparse, *Mesidotea* occurs almost everywhere in the Bothnian Bay, and is locally even common. The suspected underestimation is, however, not likely to be very large, as most other authors, except Hessle, show mean values below or not much above 1 $g \cdot m^{-2}$.

On the whole the macrofauna of the Bothnian Sea shows greater similarities to that of the northern Baltic proper (cf. e.g., Ankar and Elmgren 1975), than to the highly impoverished macrofauna of the Bothnian Bay.

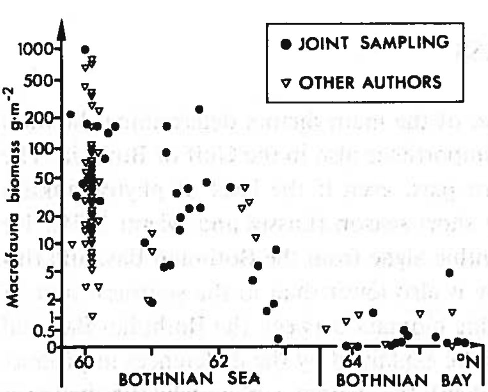

Fig. 11. Macrofauna biomass from south to north in the Gulf of Bothnia, recalculated as $g \cdot m^{-2}$ (see text for further details).

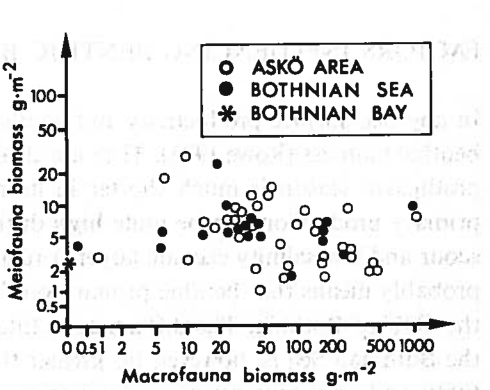

Fig. 12. Relationship between macrofauna biomass (formalin wet weight) and meiofauna biomass (wet weight), both recalculated as $g \cdot m^{-2}$, at random stations in the Gulf of Bothnia and in the Askö-Landsort area (northern Baltic proper, from Ankar and Elmgren 1975).

MEIOFAUNA

Our programme gave the first quantitative meiofauna results from the Gulf of Bothnia. A comparison with data from the Askö—Landsort area in the northern Baltic proper (around 58°50' N) (Ankar and Elmgren 1975), show a striking similarity with our results from the Bothnian Sea (Table 4) for both biomass and abundance of all major groups. The only really noticeable differences are higher temporary meiofauna biomass (2.3 against 0.7 g $\cdot$ m^{-2}) and lower ostracod biomass (2.1 against 3.0 g $\cdot$ m^{-2}) in the Bothnian Sea. Several meiofauna taxa of importance in the Baltic proper and the Bothnian Sea seem to have their northern limit of distribution in the southernmost part of the Bothnian Bay, e.g., the kinorhynch *Echinoderes levanderi* Karling and the ostracods *Paracyprideis fennica* (Hirschmann) and *Heterocyprideis sorbyana* (Jones).

In Fig. 12 the results of Ankar and Elmgren (1975) have been added to our results and here, too, the similarity is great and confirms the conclusion that meiofauna biomass is less variable than macrofauna biomass in the Baltic.

Since the macro- and meiofauna samples in the Bothnian Bay tended to come from different parts of the area, the biomass ratio 0.4 mentioned earlier must be viewed with great caution. Supplementary information from other authors (macrofauna) and semi-quantitative samples (meiofauna), as well as the probably lower sampling efficiency for the meiofauna still makes it fairly certain, however, that meiofauna has higher biomass than macrofauna in the Bothnian Bay as a whole.

That the macrofauna results of the "Joint sampling programme" agree well with previous investigations, indicates that the randomly selected stations were representative of the area investigated and it thus seems reasonable to believe that the picture of the meiofauna of the Gulf of Bothnia presented here is also true in its main outlines.

FACTORS INFLUENCING BENTHIC BIOMASS

In any sea, surface productivity and depth are two of the main factors determining the total benthic biomass (Rowe 1973). They are clearly of importance also in the Gulf of Bothnia. The productive season is much shorter in its northern part, even if the level of phytoplankton primary production can be quite high during the short season (Lassig and Niemi 1975). Ice scour and low salinity exclude larger perennial benthic algae from the Bothnian Bay, and this probably means that benthic primary productivity is also lower than in the southern part of the Gulf of Bothnia. The difference in total benthic biomass between the Bothnian Bay and the Bothnian Sea is, however, far greater than can be explained by the differences in productivity, and since biomass normally decreases with depth this cannot explain why the shallower Bothnian Bay is so poor in benthos.

The salinity decrease is the main factor progressively excluding many species, most importantly the bivalves, as we go from south to north along the Gulf of Bothnia (Segerstråle 1957, Haahtela 1974). Normally, in a situation like this, we would expect other animal species to fill the niches left open by the exclusion by abiotic factors of dominant members of the benthic community. In most of the Bothnian Bay, however, there exist no filter feeding animals, like *Mytilus edulis* and *Macoma balthica* in the shallower parts of the Bothnian Sea, which can directly utilize the phytoplankton primary production. Since *Pontoporeia affinis* by its requirement of a soft bottom substratum is largely restricted to the deeper areas below the trophogenic layer, this means at least another step in the food chain before the primary production can be turned into macrofauna biomass, with lower conversion efficiency as a natural consequence. The short productive season also means that food supply will be very low for most of the year in the large areas with sandy bottoms, where little detritus accumulates. This may be one reason for the importance of the harpactacoids in the Bothnian Bay, since with their short generation times (Heip 1972) they can rapidly increase to utilize the abundant, but short lived food supply during the summer.

The Bothnian Bay is quite unusual in having larger meiofauna than macrofauna biomass, but bears out Gerlach's (1971) generalization that meiofauna is quantitatively more important relative to macrofauna in brackish water than in marine areas. The same is also the case in the deep sea (Thiel 1972) and a possible reason for this may be true also for the long Bothnian Bay winters, namely that small animals may better utilize a sparse and finely particulate food source, such as organically poor bottom sediments.

Since both meio- and macrofauna in the Bothnian Sea are similar to those of the northern Baltic proper, but quite different from those of the Bothnian Bay, it is clear that special studies of the benthic ecology of the Bothnian Bay are imperative if the functioning of this part of the ecosystem, and the ways in which man influences it, are to be understood. In these, special emphasis should be placed on the meiofauna. For the Bothnian Sea, on the other hand, considerable extrapolation from research in the northern Baltic proper may be possible.

Acknowledgements

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Note

This paper was originally presented at the Fourth Baltic Symposium on Marine Biology in Gdansk, October 1975 and intended for inclusion in the Proceedings of that meeting. Since that publication has been indefinitely delayed and the present paper has been quoted fairly often as "in press", it was considered useful to publish it here instead, in its original form.

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ZINC AND COPPER CONCENTRATIONS IN BENTHIC INVERTEBRATES CONSIDERED IN RELATION TO CONCENTRATIONS IN SEDIMENTS AND WATER IN THE BOTHNIAN SEA (NORTHERN BALTIC)

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ABSTRACT

The zinc and copper contents in two benthic crustaceans, *Pontoporeia affinis* and *Mesidotea entomon*, were examined, in relation to the concentrations in the sediments and water in the open parts of the Bothnian Sea. The metals were determined in different size-classes of *M. entomon*, to study possible accumulation of zinc and copper.

The contents of zinc and copper in the species fell within the ranges reported in earlier studies. Both species seem to be unsuitable as indicators of zinc and copper pollution, since similar concentrations have been reported from polluted coastal sea areas. No clear accumulation of the metals was observed in *M. entomon* with increasing age, which points to physiological regulation of these essential metals, as in some other benthic crustaceans. There was, however, some indication of copper accumulation in older *M. entomon* at the site with the highest biological availability of the metals.

The metal contents in the species showed negative correlations with the contents in the sediments. This is attributed to differences between the sites in the bioavailability of sedimentbound zinc and copper. The bioavailability seems to be lower at deeper sites where the contents of iron and manganese in the sediments are higher. The contents of zinc and copper in the sediments at the three sites increased highly significantly with increasing water depth and decreasing dry matter content.

INTRODUCTION

Unlike many contaminants, heavy metals are normal constituents of aquatic environments and some, e.g. zinc and copper, are essential to the normal life of organisms. But although traces of most heavy metals are found in marine animals, they are toxic even in comparatively "low" concentrations and some are readily accumulated (e.g. cadmium, mercury and lead) in organisms.

Much of the information available on heavy metals in aquatic invertebrates comes from studies of lethal concentrations or tolerance limits, mostly made in artificial environments. It is difficult to apply the results of such studies to the evaluation of the physiological and ecological consequences of heavy metals in aquatic ecosystems. A proper understanding of the cycling of trace elements in the aquatic environment requires knowledge of the distribution of these elements in water, sediments and the biota.

The aim of the present study was to examine the zinc and copper concentrations in benthic invertebrates in relation to the concentrations in the sediments and water inhabited by the animals. The species studied were the amphipod *Pontoporeia affinis* Lindström and the isopod *Mesidotea entomon* (L.). In the Bothnian Sea, *P. affinis* is numerically predominant in the macrobenthic communities, while the large *M. entomon* often makes the greatest contribution to the biomass (Andersin *et al.* 1977). Zinc and copper were determined in different size-classes of *M. entomon* to reveal any possible dependence of the metal contents or accumulation on age. The metal contents were also determined on a few samples of *Halicryptus spinulosus* V. Siebold (Priapulida) and *Harmothoë sarsi* (Malmgren) (Polychaeta).

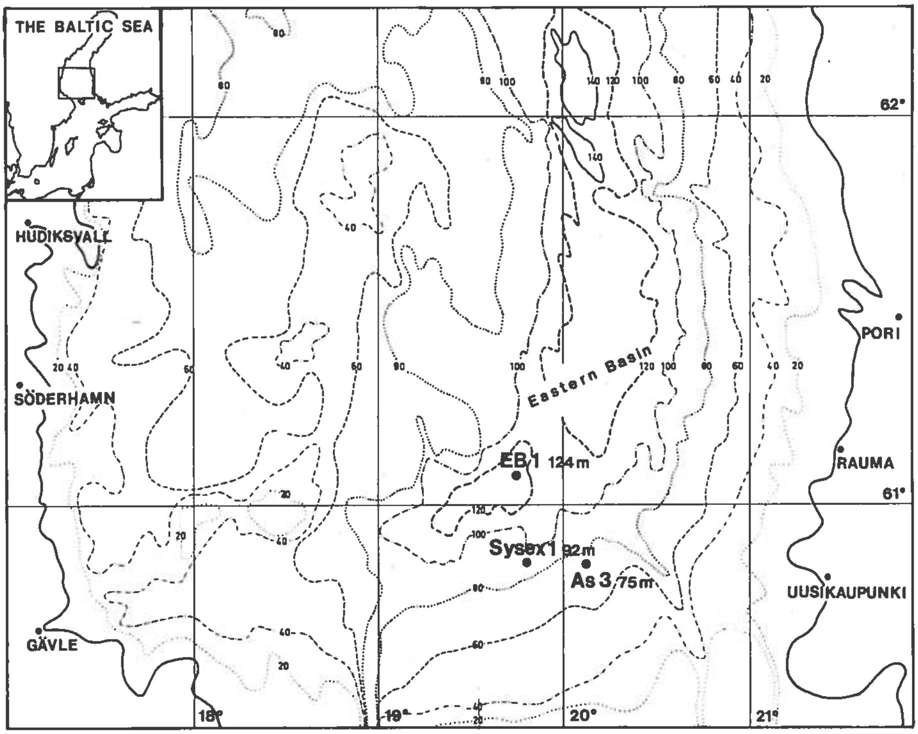


Fig. 1. The study area and the sampling stations. Bathymetric map according to Winterhalter (1972).

MATERIALS AND METHODS

STUDY AREA

The Bothnian Sea is isolated from the Baltic Proper by shallow sills, which prevent the water from the deeps of the Baltic Proper from penetrating into the Bothnian Sea. The saline water flowing into the Bothnian Sea originates mainly from Baltic surface water, the salinity being c. 7 ‰. No sharp halocline is formed and in winter thermal convection occurs through almost the whole water column. Consequently, the oxygen concentration seldom decreases below 60—80 % of saturation and anoxic conditions have never been recorded (Niemistö *et al.* 1978). The surface layers of the sediments are always oxidized, and the redox potentials exceed +250 mV (Bågander and Niemistö 1978).

SAMPLING PROCEDURES

Sampling of water, sediments and benthic invertebrates was performed at three sites in the Eastern Basin, which is the largest sedimentation basin in the Bothnian Sea (Fig. 1). The stations have a depth gradient (75, 92, 124 m) and thus represent different sedimentation conditions.

The sampling was carried out onboard the R/V Aranda between November 1978 and January 1979. The positions and hydrographical conditions at the sampling sites are shown in Table 1.

TABLE 1. The positions, depths and hydrographical conditions at the sampling sites at the time of sampling.

Station	Position		Depth (m)	Temp. °C	S ‰	O_2 ml/dm³
As 3	60°51.6'	20°07'	75	5.15	6.15	8.57
Sysex 1	60°51.6'	19°48'	92	5.09	7.20	7.51
EB 1	61°04'	19°44.5'	124	4.72	7.39	8.20

Five parallel water samples were taken from each station from 1 m above the bottom and stored in PVC bottles. Before storage, the metals were coprecipitated with 10 ml of 0.1 N NaOH (Koroleff 1980).

The sediment samples were taken with the gravity corer designed by Niemistö (1974). Each sample was sliced into five 1 cm thick sections from the surface of the sediments downwards and each section was analysed for Zn, Cu and dry matter content. Five parallel samples were taken from each site, and stored deep-frozen until further treatment.

P. affinis was sampled with a van Veen grab. Five parallel samples were collected at each site. In order to remove sediment and other foreign matter, such as faeces, the specimens were kept alive in glass containers with surface water, for 12 hours, after which the samples were kept deep-frozen until further treatment. One additional sample was sieved quantitatively at each station to determine the abundance and size distribution of the *P. affinis* populations. *M. entomon* was sampled with nets baited with herring (Haahtela 1978) and left on the bottom for three hours. The specimens were kept alive in glass containers with surface water for 12 hours, measured with an accuracy of 1 mm, sorted into size-classes in different PVC containers and kept deep-frozen until further treatment. A few specimens of different sizes were deep-frozen immediately for determination of stomach contents.

ANALYTICAL PROCEDURES

The Zn and Cu concentrations in the water, sediments and biological samples were determined by atomic absorption spectrometry (Perkin Elmer 300).

When the water samples were analysed for Zn, the spectrometer was equipped with a standard burner head (the flame mode). For determination of Cu, the spectrometer was supplied with a heated graphite atomizer (HGA 72) and D_2 compensator. The anlytical procedures are described in detail by Koroleff (1980). The concentrations are expressed as μg metal/dm³ H_2O.

The deep-frozen sediment samples were first freeze-dried, and then homogenized in an agate mortar. 10 ml of 65 % HNO_3 (suprapure) was added to 1 g of the homogenized sediment and then heated for 30 min. under pressure. Finally the sample was diluted with 40 ml of distilled water prior to analysis. When the sediment samples were analysed for Zn and Cu, the spectrometer was equipped with a standard burner head.

The biological samples were extracted and analysed in the same way as the sediment samples. Two specimens of *M. entomon* were homogenized together for each analysis. The results for both sediments and animals are expressed as μg metal/g dry weight.

The results are presented as the means and standard deviation ($\overline{X} \pm SD$) of the parallel samples. The two-tailed t-test was used in the statistical comparisons.

RESULTS

The concentrations of Zn in the water samples from the three sites varied between 2.0 and 11.8 $\mu g/dm^3$ (Table 2). The concentrations of Cu varied between 0.9 and 1.6 $\mu g/dm^3$ (Table 2). The means of the three stations did not show any statistically significant difference.

TABLE 2. Concentrations of zinc and copper ($\mu g/dm^3$) in the water 1 metre above the bottom. The values are the means of five observations. X——X = significant difference.

	ZINC ($\mu g/dm^3$)			COPPER ($\mu g/dm^3$)		
Site	As 3	Sysex 1	EB 1	As 3	Sysex 1	EB 1
Depth (m)	75	92	124	75	92	124
X ± SD	2.5 ± 0.8	4.6 ± 2.5	7.1 ± 3.5	1.2 ± 0.3	1.2 ± 0.1	1.1 ± 0.2
	X———	———X				
	X———	———	———X			

The zinc and copper contents of the sediments are shown in Fig. 2. Highly significant differences were obtained in all cases, when the total mean concentrations (slices 1—5 cm) were compared between the different sites. The contents of zinc and copper in the sediments increased with increasing water depth of the sampling site. The zinc/copper ratios in the sediments were, however, similar at all sites.

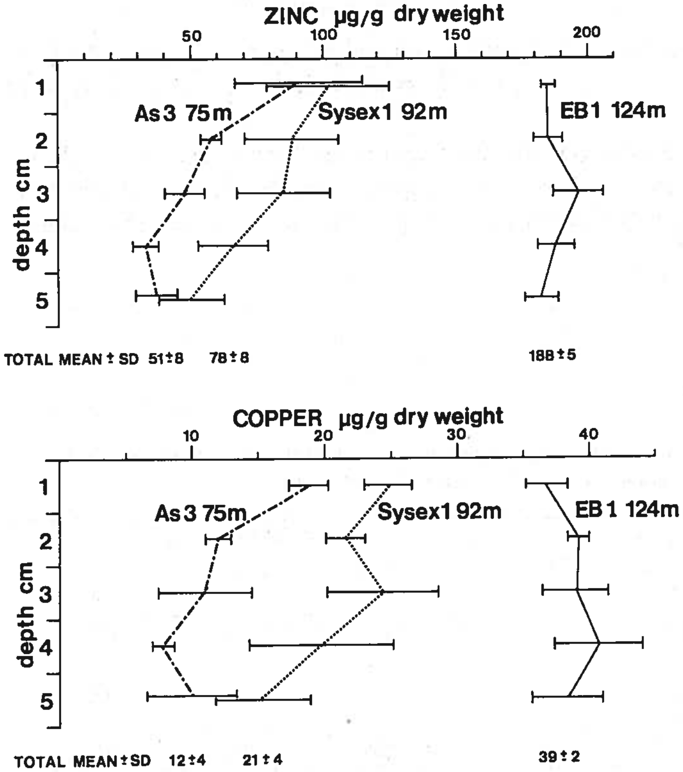


Fig. 2. Zinc and copper concentrations of the sediments from the surface downwards. The values are the means of five samples, the horizontal bars indicate the standard deviation. For stations see Fig. 1.

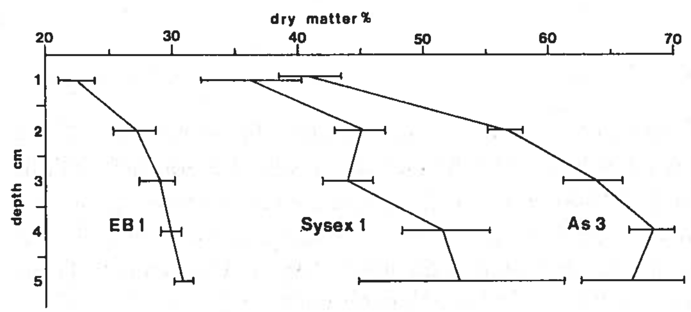


Fig. 3. Vertical distribution of the dry matter content of the sediments. The values are the means of five samples. The horizontal bars indicate the standard deviation. For stations see Fig. 1.

The content of dry matter in the sediments is shown in Fig. 3. The lowest values were found in the topmost centimetre at all sites. The means of the sites differed significantly.

The size distributions of *P. affinis* were very similar at the three sites. Thus the differences in the zinc and copper contents of *P. affinis* between the sites were not caused by differing age structures.

The Zn contents in *P. affinis* varied between 56 and 137 μg/g on a dry weight basis (Table 3). The means of the five parallel samples at each station differed significantly, except between station Sysex 1 and EB 1.

The Cu concentrations in *P. affinis* varied between 90 and 130 μg/g dry tissue (Table 3). The means of the five parallel samples of each station differed significantly, except between As 3 and Sysex 1.

The size distributions of *M. entomon* at sites As 3 and Sysex 1 were very similar. At EB 1, however, the material was too scarce to draw any conclusions regarding the size distribution. Only one big specimen (74 mm) and 31 small specimens, all with a length of less than 25 mm, were caught at this site.

TABLE 3. Concentrations of zinc and copper (μg/g dry weight) in *Pontoporeia affinis* from the different sampling stations. X——X = significant difference.

	ZINC (μg/g)			COPPER (μg/g)		
Station	As 3	Sysex 1	EB 1	As 3	Sysex 1	EB 1
Depth (m)	75	92	124	75	92	124
	108	62	60	108	109	92
	73	60	56	114	109	91
	102	58	56	130	113	90
	137	99	56	111	100	96
	68	59	56	108	104	92
X ± SD	98 ± 28	68 ± 18	57 ± 2	114 ± 9	107 ± 5	92 ± 2
	X———	———X		X———	———	———X
	X———	———	———X		X———	———X

The analyses for zinc (n=66) made on *M. entomon* gave values varying between 42 and 108 μg/g. At site As 3, the means for animals of different sizes (ages) did not differ (Table 4). Nor could any difference be demonstrated between the size-classes at site Sysex 1. At As 3 the total mean content of zinc in *M. entomon* was significantly higher than at Sysex 1. The two zinc analyses of *M. entomon* at site EB 1 showed the lowest values. The content of zinc in the small specimens was 63 μg/g and the one big specimen contained only 42 μg/g.

TABLE 4. Concentrations of zinc and copper (μg/g dry weight) in *Mesidotea entomon.*

	ZINC						COPPER					
Station	As 3			Sysex 1			As 3			Sysex 1		
Depth (m)	75			92			75			92		
Length of specimens	$\bar{X} \pm SD$		n	$\bar{X} \pm SD$		n	$\bar{X} \pm SD$		n	$\bar{X} \pm SD$		n
36—45 mm	82	5	5	74	8	5	160	20	5	106	10	5
46—55 "	74	7	7	71	8	10	167	24	7	105	17	7
56—65 "	78	10	15	75	7	9	158	16	15	126	22	10
66—75 "	90	13	5	67	12	4	220	49	5	126	13	5
76—85 "	82	12	2	68	6	4	242	150	2	127	14	4
Total	81	6	5	71	4	5	189	39	5	118	11	5

The total range of the copper contents of *M. entomon* was 64—349 μg/g. At As 3 the lowest mean contents were found in the smallest size-classes (34—45 mm, 46—55 mm, 56—65 mm). The means for the size-classes 66—75 mm and 76—85 mm were significantly higher. At Sysex 1 also the Cu contents were lowest in the two smallest size-classes (36—45 mm, 46—55 mm). In all size-classes the values were significantly higher at As 3 than at Sysex 1. Consequently, the total mean was higher at As 3. Only two analyses were made on the very sparse material of *M. entomon* from station EB 1. The mean content of Cu in the 31 small specimens was 147 μg/g, and the one big specimen contained only 64 μg Cu/g.

One zinc and copper analysis was performed on 7 big specimens of the priapulid *Halicryptus spinulosus* from site EB 1. The zinc content was 213 μg/g, and the copper 45 μg/g. The metals were also determined on a pooled sample of 50 specimens of the polychaete *Harmothoe sarsi* (length = 5—48 mm) from site EB 1. The zinc content was 85 μg/g, and the copper 45 μg/g.

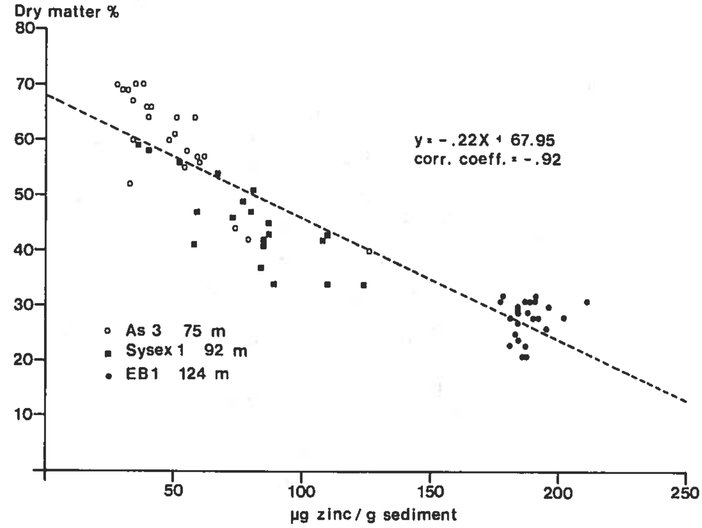
DISCUSSION

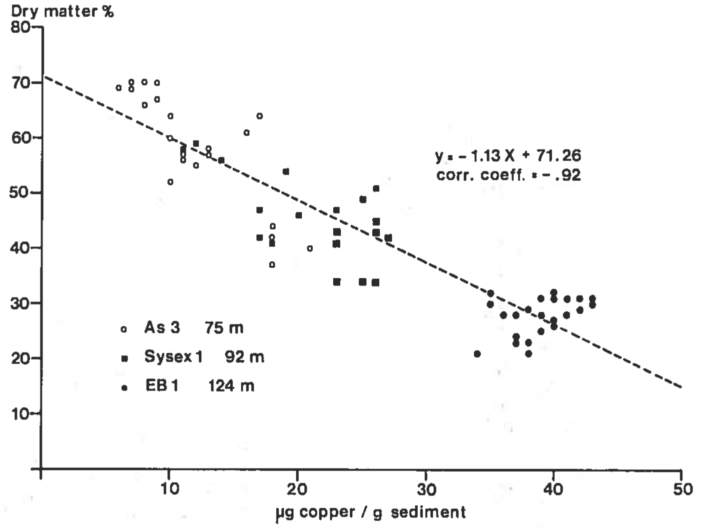
Because of the extremely low concentrations of most heavy metals in organisms, sediments and especially waters, many problems are still involved in the quantification of the concentrations. Great caution must thus be exercised in interpreting results from different studies.

The present study deals with "total" concentrations of zinc and copper in the bottom water. The mean values of zinc (4.7 μg/dm^3) and copper (1.2 μg/dm^3, Table 2) fall within the ranges reported for the Baltic Sea by Melvasalo *et al.* (1981): 1—7 μg/dm^3 and 0.3—3.0 μg/dm^3, respectively. The zinc contents of the bottom waters increase with increasing contents in the sediments (Table 2 and Fig. 2), while the values for the less soluble copper do not reflect an increase in the sediment contents. Lithner and Samberg (1976) also observed that zinc was more mobile than copper in the Gulf of Bothnia. The low contents of zinc and copper in the water layer above the sediment surface indicate that the dense *P. affinis* populations at the sites did not cause resuspension of sediments resulting in release of metals in the near bottom water. *P. affinis* rises from the bottom, mainly at night, however, when it swims around in the overlying water (e.g. Wells 1968). The present sampling was carried out during daytime and thus the effect of nighttime bioturbation is difficult to estimate.

As in the present study (sites As 3 and Sysex 1, Fig. 2), the superficial sediments very often show higher heavy metal contents than layers deeper down. It is still an open question whether this phenomenon is caused by increased sedimentation or by geochemical intrasedimentary processes resulting in metal enrichment towards the sediment surface. The total mean contents of zinc and copper in the sediments (Fig. 2) agree well with results from other studies from the open sea area of the Gulf of Bothnia (Niemistö and Tervo 1978, Niemistö and Voipio 1981 and Voipio and Niemistö 1979).

Fig. 4. Correlation between dry matter content (%) and zinc and copper contents of sediments at the different sites (μg/g dry sediment).





The increase of sediment zinc and copper with increasing water depth (Fig. 2) is probably caused by a combination of the following factors. The conditions at the sites are different. Site EB 1 is situated in the deep centre of the Eastern Basin (Fig. 1), while Sysex 1 and As 3 lie on the slopes of the basin. Towards the centre of the basin the dry matter contens of the sediments (Fig. 4) decrease, while the metal contents in dry matter simultaneously increase. The tranquil environments in the deeper areas evidently permit the deposition of both organic particles (very high water content) and fine-grained inorganic particles. Fine particles adsorb metals more than big ones, due to their larger area-to-volume ratio. Also, the amount of organic carbon in sediments has been observed to correlate with the amount of zinc and copper (e.g. Cato 1977, Hallberg 1979). The organic carbon content at the deepest site EB 1 is c. 3 ‰ on a dry weight basis and lower at Sysex 1 and As 3 (IMR unpublished). Suspended inorganic matter, containing mainly iron and manganese oxides, has been reported to be the main sink for heavy metals in general in the Gulf of Bothnia (e.g. Hallberg 1979). The higher contents of iron and manganese oxides in sediments at deeper sites (Boström *et al.* 1978, Niemistö *et al.* 1978) are associated with higher amounts of zinc and copper.

The heavy metal contents recorded for *P. affinis* and *M. entomon* from the Gulf of Bothnia have been compiled in Table 5.

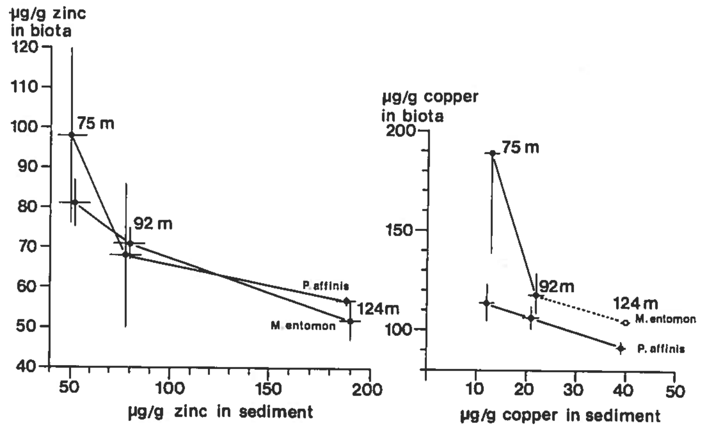
The study of Lithner (1974) was carried out in a coastal area of the Bothnian Bay polluted by heavy metals from the metal industry. The zinc values for *P. affinis* are of the same order as in the present study, while the copper values seem to be higher. Lithner reported that the guts of the *P. affinis* specimens may have been contaminated with sediment, which would raise the metal values. The studies of Häkkilä (1980) and Niemi (1977) also deal with coastal areas polluted by heavy metals, but the zinc and copper contents of *M. entomon* were of the same order as in the present study. The wide ranges of the values in Table 5 make it difficult to draw conclusions based on differences between localities. It seems, however, that neither *P. affinis* nor *M. entomon* are suitable indicators of zinc or copper pollution.

TABLE 5. Contents of zinc and copper ($\mu g/g$ dry matter) in *P. affinis* and *M. entomon* from the Gulf of Bothnia.

Author	Area	*Pontoporeia affinis* Zn	*Pontoporeia affinis* Cu	*Mesidotea entomon* Zn	*Mesidotea entomon* Cu
Present study	Bothnia Sea open areas	56—137	90—130	42—108	64—349
Lithner (1974)	Bothnia Bay Bay of Skellefteå	50—100	120—195		
Niemi (1977)	Bothnia Bay off Kokkola			104—125	194—268
Voipio *et al.* (1977)	Bothnia Sea open areas			69—114	122—240
Häkkilä (1980)	Bothnia Sea off Pori			108—154	65—206
Tervo *et al.* (1980)	Gulf of Bothnia			62— 93	164—258
Kauppinen (1980)	The Quark off Vaasa			87— 97	159—170

According to the present study, the zinc and copper contents of the two species at the different sites follow similar patterns (Fig. 5). This seems natural in view of their more or less similar physiology. Both species spend most of their life in the sediments. *P. affinis* is a detritivorous deposit feeder (Ankar 1977) while *M. entomon* is a carnivore. In the present study, the main food items of the latter were observed to be *P. affinis* and the ostracod *Paracypreides fennica.*

Fig. 5. Correlation between zinc and copper contents in biota (*P. affinis* and *M. entomon*) and sediments at the different sites (75 m = As 3, 92 m = Sysex 1, 124 m = EB 1). The vertical and horizontal lines indicate the standard deviations. o = only two copper analyses of *M. entomon*.



The specimens with the highest zinc and copper contents come from the shallowest site, with the lowest metal contens in the sediments (Fig. 3). The specimens with the lowest metal contents come from the deepest site, with the highest metal contents in the sediments. The most probable reason for these seemingly contradictory results is different bioavailability of sediment-bound zinc and copper at the sites. In the present study the total contents of the metals in the sediments were determined and this may be misleading when bioavailability is estimated. Due to the chemical form in which metals occur, they may be less available to organisms in sediments with high total contents, than in sediments with low total contents. Luoma and Jenne (1977) observed that the type of substrate to which a metal is bound may strongly affect its availability to bivalves. They noted that the uptake of zinc by the deposit feeder *Macoma baltica* was related to the iron oxide content of the sediments. Luoma and Bryan (1978) suggested that the high capacity of insoluble iron oxide for binding lead, makes lead less available to the burrowing bivalve *Scrobicularia plana* with increasing iron content of the sediments. Bryan and Uysal (1978) observed lower values of Fe and Mn environments where the bioavailability of other heavy metals was high. According to Langston (1980) the proportion of readily extractable Fe (1 N HCl) affected the bioavailability of As in such a way that the highest As contents in organisms were found at those sites where high As/Fe ratios existed in the sediments. Although conclusive evidence is lacking, the mechanism is supposed to operate along similar lines as concerns zinc and copper, which should thus be less available to sediment-dwelling organisms when the iron content of the sediments is high. Boström *et al.* (1978) reported that Fe_2O_3 fluctuates widely in the Gulf of Bothnia, from 2—4 % in shallow areas to 10—14 % in some deep areas, and that MnO shows an almost exponential increase with depth of the deposits. Niemistö *et al.* (1978) also observed that the iron content of sediments in deeper areas of the Bothnian Sea is higher than in shallow areas. At site EB 1 the iron content has been reported to be about 6 % (dry weight) (Niemistö *et al.* 1978). Consequently, the higher content of Fe in deeper areas of the Bothnian Sea may lower the availability of trace metals such as zinc and copper to benthic invertebrates, in spite of comparatively high total contents of these elements in the sediments.

The negative correlation between the contents of zinc and copper in *P. affinis* and *M. entomon* and in the sediments (Fig. 5) shows clearly the weakness, from an ecological point of view, of effective total extraction of metals from sediments. If one wishes to study the influence and possible uptake and concentration of various metals in benthic organisms, it is advisable to determine the metal contents in, for example the sediment portion serving as a food source for the organisms studied. In several studies the readily extractable fraction (1 N HCl) has been considered a gross estimate of the amount of metals available to organisms (e.g. Cross *et al.* 1970, Luoma and Bryan 1978). The literature presents several other "weak" extraction methods for determination of the bioavailable fraction of heavy metals in sediments (Loring 1981 and references therein). Loring (1981) reported that only 8—39 % of the total zinc and 5—21 % of the total copper was potentially available to the biota of eastern Canadian estuarine and coastal sediments. In the Bothnian Bay "weak" extraction of sediments (0.5 N HCl, cold extraction) revealed that most of the copper was potentially bioavailable, while the "weak" fraction was observed to be smaller in the southern Baltic (Brügmann *et al.* 1982). However great attention must be paid to areal, methodological and biological differences between species in comparing studies concerning the bioavailability of heavy metals in sediments. *P. affinis* and *M. entomon* spend much of their time buried in the sediments and thus a suitable measure of the bioavailable amount of heavy metals is the contents in the interstitial water (pore water). At EB 1 the mean zinc and copper contents of the pore water of the five uppermost centimetres of the sediments have been observed to be 40 $\mu g/dm^3$ and 7 $\mu g/dm^3$, respectively (IMR unpublished). At the two other sites the pore water has unfortunately not been analysed for zinc or copper.

It has been confirmed in several studies (e.g. Bryan 1976, Phillips 1977) that the rates of absorption of heavy metals by organisms increase as the salinity is lowered. Metals are also absorbed more rapidly by organisms at higher temperatures (Bryan 1976 and references therein). The importance of higher salinity and lower temperature (Table 1) to the low metal contents observed in the specimens (Table 3, 4) from the deepest site is, however, difficult to estimate within the framework of the present study.

Concentration factors, defined as weight of metal per unit animal (dry weight) over weight of metal per unit sediment (dry weight), were calculated for *P. affinis* and *M. entomon* both from the results of the present study and from results from other parts of the Gulf of Bothnia (Table 6). In the present study the contents of the metals in the sediments varied considerably more between the sites than the contents in the organisms. The Zn and Cu sediment contents reported by Häkkilä (1980) were considerably higher than in the present study, but the contents of Zn and Cu in *M. entomon* were of the same order. Consequently it seems that *M. entomon* concentrates the metals to a lesser extent when the contents in sediments are high.

The great variation in the concentration factors of *P. affinis* and *M. entomon* might be due not only to differing bioavailability of metals in the sediments, but to some mechanism regulating the Zn and Cu levels in the organisms, so that they tend to reach equilibrium regardless of the surrounding media. Bryan (1964, 1966, 1967) observed zinc regulation in some species of decapod crustaceans and suggested that zinc and perhaps copper are requlated in all species (Bryan 1968).

TABLE 6. Concentration factors of zinc and copper for *Pontoporeia affinis* and *Mesidotea entomon* (wt of metal per unit sediment dry wt) *) calculated from values of Lithner (1974), **) Häkkilä (1980), and ***) Kauppinen (1980).

		ZINC		COPPER	
Station	depth (m)	*P. affinis*	*M. entomon*	*P. affinis*	*M. entomon*
As 3	75	1.9	1.6	9.5	15.8
Sysex 1	92	0.9	0.9	5.1	5.6
EB 1	124	0.3	0.3	2.3	2.8
3 *)		2.0		9.3	
18 *)		1.4		11.8	
19 *)		0.9		9.2	
26 *)		2.1		8.6	
77 *)		3.1		10.0	
**)			0.4		2.6
**)			0.4		2.2
Nagelprick ***)			0.4		4.8
Varisselkä ***)			0.2		3.7
$\overline{X} \pm SD$		1.6±0.9	0.6±0.5	8.2±3.0	5.4±4.8

Anderson and Brower (1978) studied concentrations of zinc, copper, lead and cadmium in the crayfish *Orconectes virilis* from sites with different inputs of metals. They also suggested regulation of zinc and copper but not of lead or cadmium. Another fact in the present study that points to regulation, at least of zinc, is the similar content of zinc and copper in *M. entomon* of different sizes (ages) (Table 4). The age of the specimens of the smallest size-class is about one year and that of the oldest specimens (76—85 mm) is several years. However, one exception that indicated elevated concentrations is the copper contents of the oldest specimens at site As 3, where the bioavailability of metals is considered highest.

Tervo *et al.* (1980) also reported a high copper content in a very large (92 mm) specimen of *M. entomon.* On the other hand, great variation was observed in the present study in the copper contents (64—349 μg/g) of the largest size-class. In the total analyses the largest specimens had both the lowest and highest values for copper. McCrimmon and Bray (1962) observed that in old, big specimens of *M. entomon* the digestive tract was invariably empty, the exoskeleton appeared soft and the internal organs were degenerate. This might result in disturbed copper metabolism in old specimens. Zuckerkandl (1960) observed that the crab *Maja squinado* lost up to half its content of copper during one molt. If the same is true of

M. entomon, then the higher contents of copper in old specimens seem natural, as their growth is very slow (Haahtela 1977) and the periods between the molts are very long.

It apperas that future studies should be devoted to gaining more information on the behaviour of non-essential heavy metals, such as cadmium, mercury and lead, in aquatic animals; these organisms might be expected to cope more efficiently with essential and relatively abundant metals, such as copper and zinc, than with non-essential metals, which have a low natural abundance.

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ACANTHOCYCLOPS ROBUSTUS (COPEPODA, CYCLOPOIDA) IN PLANKTON OF THE HELSINKI SEA AREA, AND A MORPHOLOGICAL COMPARISON BETWEEN A. ROBUSTUS AND A. VERNALIS

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ABSTRACT

Abundant *Acanthocyclops robustus* (G.O. Sars) have been found in plankton of the eutrophicated bays of the Helsinki sea area since the late 1960s. The species is of the "setosus" type, which differs from the form described originally, and in many respects resembles *A. vernalis* (Fisher). A morhological comparison with figures is therefore given for both species pointing out the distinguishing characteristics presented by Kiefer (1976). The specimens of *A. vernalis* originate from a rock pool in the archipelago of Tvärminne Zoological Station (western Gulf of Finland). The number of chromosomes of the *Acanthocyclops* species in Helsinki is 2n = 10. This result differs from the earlier value (2n = 6) given for *A. robustus* by Rüsh (1960). The mass occurrence of cyclopoids (maximum of all developmental stages 800—1000 ind./dm^3 and dominance >90 %) seemed to be associated with the current eutrophication in the sea area of Helsinki. The hydrographical parameters that were found to have the most marked effect on the yearly variation on the abundance of cyclopoids in one of the most eutrophicated bays were phytoplankton biomass, phosphorus concentration and salinity.

INTRODUCTION

In Finnish coastal waters, especially in the inner archipelago and bay areas of low salinity, only two cyclopoids, *Mesocyclops leuckarti* and *Thermocyclops oithonoides,* have been found regularly, however, in low densities, among other limnic species (cf. Levander 1915, Halme 1958). Earlier, the same situation prevailed in the Helsinki sea area as well. In quantitatively analysed material taken from the Helsinki sea area in 1920 cyclopoids occurred sparsely, being found merely in the inner bays of lowest salinity, which in those days were still relatively undisturbed (Välikangas 1926).

When zooplankton studies connected with the monitoring of the Helsinki sea area were initiated by the Water Laboratory in the late 1960s, cyclopoids were found to be surprisingly abundant in the eutrophicated bay areas. In 1969, then undetermined cyclopoids constituted c. 90 % of the total zooplankton biomass in Laajalahti in July — August (Fig. 1, A); they were also abundant in Vanhankaupunginselkä (B) and Seurasaarenselkä (D), but very scarce in the outer archipelago (Vesiensuojelulaboratorion tiedonantoja 1970). The most common cyclopoid species was determined as *Cyclops (Acanthocyclops) vernalis* in the report for 1970 (Viljamaa 1971). The same name was used for the species in later papers as well (Viljamaa 1972a, b, 1973, 1974, 1975, 1976, Melvasalo & Viljamaa 1975, Melvasalo *et al.* 1975, Eerola 1979). From the start however, we were struck by the fact that this species, which normally occurs in littoral and small ponds, was found in plankton in this area. It was also confusing that at the same time, some of its morphological features referred, even conflictingly, to *A. robustus,* which, according to other researchers, e.g. Rylov (1948, 1963), is a variety of *A. vernalis.* In addition, the *A. robustus* (G.O. Sars) described e.g. by Dussart (1969), differs from the Helsinki species, with regard to the definition given in the key.

Since then Kiefer (1976, 1978) has carried out the comprehensive investigations of the taxonomy of the group *A. robustus — vernalis* and given a new description. He has excluded from this group the former third member, *A. americanus* (Marsh), which he considers to be a result of a confusion between *A. robustus* and *A. vernalis.*

The plankton material of the bays in the Helsinki sea area is now reconsidered in the light of these new data. We have come to the conclusion that the species in question is *A. robustus,* most specimens being of the "setosus" type.

In this paper the most characteristic features of and differences between the two closely related species, *A. robustus* and *A. vernalis,* are described from material originating in the coastal waters of the Gulf of Finland. Also dealt with is the occurrence of the planktonic cyclopoids, of which *A. robustus* constitutes the great majority, in relation to some environmental factors in the highly eutrophicated bays of the Helsinki sea area.

IDENTIFICATION OF *A. ROBUSTUS* ACCORDING TO KIEFER

The difficulties of taxonomy, which were satisfactorily solved by Kiefer (1976), arose mostly from the close similarity and contradicting variability in characteristics between *A. robustus, A. vernalis* and "*A. americanus*". In the description by Sars (1918), the characteristic feature of *A. robustus* is the transformation of the outer seta of the distal joint of endopodite (Enp_3) of the fourth leg (P_4) (also P_2 and P_3) towards a denticulate spine. According to Kiefer (1976), this phenomenon occurs in the "locus-classicus" population (Lake Mjösen, north of Oslo), but by no means in every population within the distribution area of the species. Kiefer (1976) found *A. robustus* individuals of the "setosus" type among the typical "aculeatus" type, even in his own study area Bodensee/Obersee (Lake Constance), and pure or nearly pure "setosus" populations in SE Europe (Greece, Rumania), Peru and USA. On the other hand, the female of *A. robustus* can certainly be identified by the shape of the fore edge of the abdomen, which is rounded at its lateral side and not angular as in *A. vernalis* (Kiefer 1976, 1978). This difference is evident in plates 25 and 26 in the study by Sars (1918). Although Kiefer (1976) stated that this difference is the only reliable mark of identification, he still enumerates some less clear characteristics (most of which are connected with Enp_3 P_4) in support of his determination: the distal joint of *A. robustus* is rather narrow and its inner spine tends to be longer than the outer spine. Furthermore, the ratio of the length of the inner spine to the length of the distal joint is 70—90 % and to its width 170—230 %, respectively.

In contrast, the distal joint of Enp_3 P_4 of *A. vernalis* is much wider than that of *A. robustus*, and both its spines are either nearly equal in length or the inner one is somewhat shorter, and its ratio to the length of the joint is 50—70 % and to its width 100—170 %.

Differences can also be seen in their ecological behaviour: both species occur in small ponds and in the littoral, but *A. robustus* can be found also in plankton as well (e.g. Rylov 1948, 1963, Vijverberg 1977, Kiefer 1978).

STUDY AREA, MATERIAL AND METHODS

Most of the material for this study was taken from the sea area of Helsinki during routine monitoring in 1969—1981. Some rock pools inthe archipelago of Tvärminne and Dragsfjärd were also studied (Fig. 1). Some samples taken earlier from the Helsinki sea area and preserved in the Zoological Museum, University of Helsinki, were microscoped for comparison.

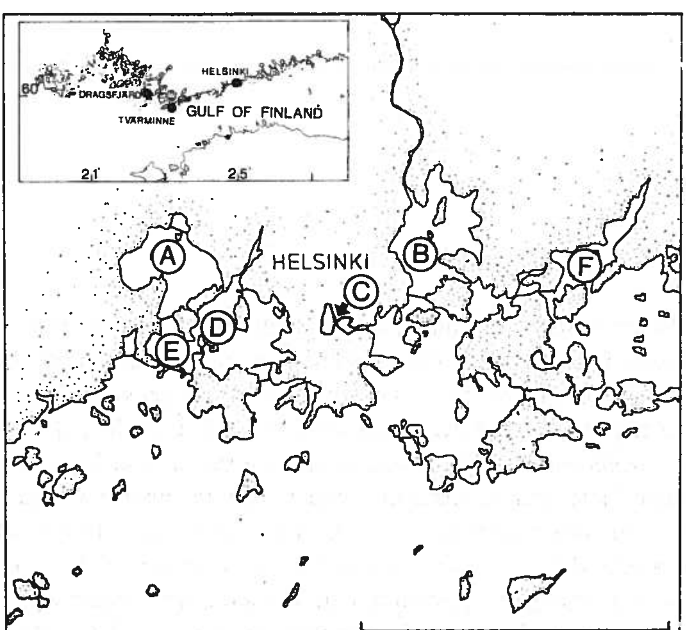

Fig. 1. Study areas. Helsinki Sea area: A = Laajalahti, B = Vanhankaupunginselkä, C = Kaisaniemenlahti and Töölönlahti, D = Seurasaarenselkä, E = Lehtisaarenselkä, F = Vartiokylänlahti.

The nearest bays around the city of Helsinki are shallow (mean depth c. 2—3 m) with a range in salinity of 2—5 ‰ in Laajalahti and 1—4 ‰ in Vanhankaupunginselkä (Fig. 1). In summer the temperature in these bays can rise above 20°C throughout the water column. The bays and the inner archipelago of Helsinki are recipients of mainly domestic sewage (nowadays biologically and chemically purified). This explains the high eutrophication with heavy blooms of blue-green algae since the beginning of regular monitoring in 1966. Further information on the physical, chemical, and biological properties, including plankton and the nutrient load discharged into the sea area of Helsinki, has been given elsewhere, e.g. in the annual reports of the Water Laboratory (Pesonen 1972, 1973, 1974, 1975, 1977), Melvasalo & Viljamaa (1975) and Melvasalo *et al.* (1975).

Most of the taxonomical and morphological work on *Acanthocyclops robustus* was done on two samples from Laajalahti: in the first (22 July, 1974) the species was very abundant (90 % of the total number of individuals), but the copepodid stages formed the majority. In the other sample (5 August, 1980), the species was less numerous, but the proportion of adults was higher. All the cyclopoid adults determined in these samples were *A. robustus.*

The species were measured on females preserved in formalin using as a criterion of maturity the structure of the genital region (fusion of the first and second segments). It was often necessary to prepare out the fourth legs and abdomen to expose the taxonomical features. No transformation was noted in the animals during the procedure. We measured the species as in Kiefer (1976): first the length of the inner spine (a) of the distal joint, and then the length (b) and width (c) of the joint. The ratios (%) a/b and a/c were calculated for more than 50 animals. For comparison, several *A. vernalis*-individuals taken on June 1980, from a rock pool near the Tvärminne Zoological Station were studied in the same manner.

A drawing tube (manufactured by Wild) was used for the morphological figures of the species.

The majority of the zooplankton samples in the Helsinki sea area were collected with a 28 litre sampler with a net (mesh size 50 μm), roughly every second week during May—October in 1969—1976 and 1980—1981. The zooplankton methods including the mean volumes of the species used for the biomass determination are described in Viljamaa (1972a) and Melvasalo *et al.* (1973).

The study of chromosomes of *A. robustus* was performed by Dr Heikki Salemaa (Department of Genetics, University of Helsinki) using the reliable Feulgen squash method on a sample taken on 14 July, 1982 from Vanhankaupunginselkä and preserved in acetic acid alcohol.

RESULTS AND DISCUSSION

MORPHOLOGY OF *A. ROBUSTUS* AND *A. VERNALIS*

The cyclopoid species, which occurs in such abundance in the plankton of the bay areas of the Helsinki sea area, was proved to be *A. robustus* (Fig. 2). The most marked characteristics of *A. robustus* demonstrated by Kiefer (1976): the rounded edge of the genital region in females, is indisputable in this material and its difference from *A. vernalis* is evident (Fig. 3). The other features reported for *A. robustus* can also be seen in animals taken from Laajalahti: Enp_3 P_4 is rather slender, its inner distal spine is somewhat longer than its outer one, and its ratios to the length and width of the distal joint (a/b=90 %, a/c=240 %) are close to the values given for *A. robustus* by Kiefer (1976). *A. vernalis* taken from Tvärminne differs from *A. robustus* in the same points. The cyclopoid population of Helsinki is characterized by "setosus" structure (Fig. 2 E—G), and the "aculeatus" type (the other seta of Enp_3 P_4, at least in its distal part, of the "spiniform" type) formed less than 10 % of the specimens studied (Fig. 2 H). The same formation applies to the spines of Enp_3 P_2—P_3 (Fig. 2 I).

To confirm the actual determination of the *A. robustus* species in the Helsinki archipelago the number of chromosomes was counted. The result was beyond all doubt 2n=10. The chromosome count was made on several goniomitotic divisions and on the prophases and metaphases of the first meiotic division in both sexes. In this respect our results seemed to be disappointing compared with the earlier results of Rüsch (1960). She determined the number of chromosomes in Central European populations in a study in which *A. robustus* (2n=6) was identified by Dr Kiefer and *A. vernalis* (2n=10) by Dr V. Brehm. In the opinion of Dr Salemaa, however, the number of chromosomes in crustaceans often varies within the species, which is why it cannot be used as a reliable taxonomical mark of identification. Our result, so different from that of Rüsch (1960) may be attributed to regional variation.

OCCURRENCE OF *A. ROBUSTUS* IN THE HELSINKI SEA AREA

To find out when *A. robustus* immigrated to the Helsinki sea area, samples preserved earlier in the Zoological Museum, University of Helsinki were studied microscopically. The only cyclopoid in the bays Kaisaniemenlahti and Töölönlahti (Fig. 1 C) in 1947 was *Mesocyclops leuckarti* in water rich in the blue-green alga *Oscillatoria agardhii* and the rotifer *Brachionus calyciflorus.* Both indicate eutrophication. No *Acanthocyclops* was found in material from Laajalahti taken by Prof. Välikangas in 1949 and 1951. This bay, too, was clearly eutrophicated in those days (viz. the presence of the rotifer *Filinia longiseta*). The situation was similar in 1957 in Taivallahti (a bay in the eastern part of Seurasaarenselkä), the fauna of which resembled that of the archipelago rather than of Laajalahti (typical species *Acartia bifilosa*), although *Filinia longiseta* and *Mesocyclops leuckarti* were also present.

The first observation on the mass occurrence of cyclopoids in the bays of the Helsinki sea area was made in 1968. In July of that year then an undetermined species exceeded the abundance of 1000 ind./dm^3 in Lehtisaarenselkä (Fig. 1 E) and 500 ind./dm^3 in Laajalahti (all developmental stages) (Selostus Helsingin ja Espoon merialueiden tutkimuksista 1968).

As reported earlier, the maximum of cyclopoids (mainly *A. robustus*) in the highly eutrophicated bays of Helsinki was 700—1000 ind./dm^3 in July—August 1969—1974 during the bloom of blue-green algae (mainly *Oscillatoria agardhii* and *O. limnetica,* and later *Microcystis reinboldii)* (Viljamaa 1974, 1975, Melvasalo & Viljamaa 1975 and Eerola 1979). The cyclopoids then accounted for up to 90 % of the total number of zooplankton individuals and of the biomass especially in Laajalahti. The other zooplankton species most typical during the cyclopoid-maximum were *Keratella quadrata* and *Synchaeta* spp. and to a minor degree *Daphnia cucullata,* the proportion of which has increased in Laajalahti since 1975.

In Laajalahti the biomass of cyclopoids in the samples in 1969—1974 was positively correlated with the biomassa of bluegreen algae ($r=0.64$, $P<0.001$) the species *Oscillatoria agardhii* ($r=0.47$, $P<0.01$) and *O. limnetica* ($r=0.71$, $P<0.001$ ($n=35$) and with temperature

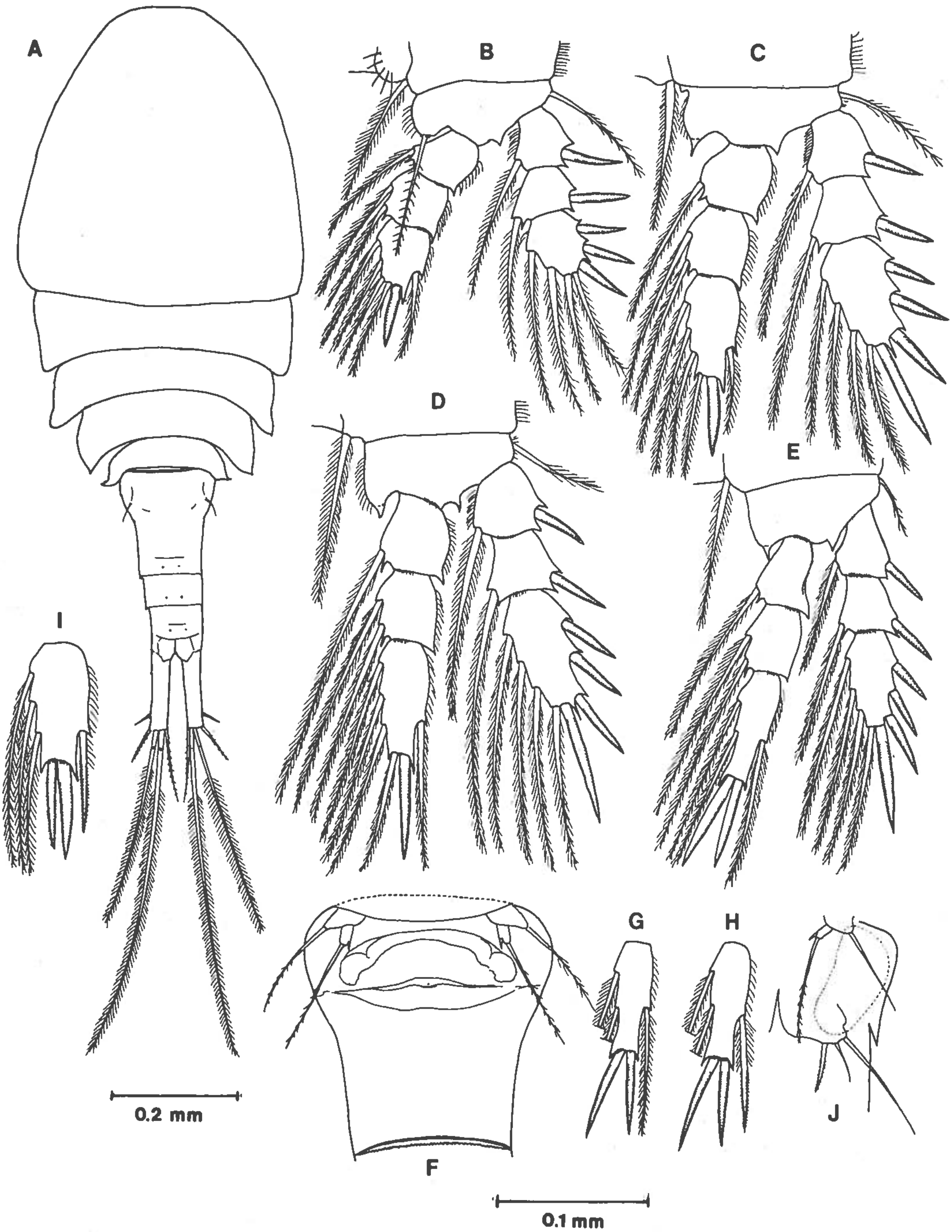

Fig. 2. *Acanthocyclops robustus* (G. O. Sars) from plankton: Helsinki, Laajalahti. A = female, dorsal view, B—E = P_1—P_4, F = P_5 and gen. reg. of female, G = Enp_3 P_4 with setiform outerseta, H = ditto with spiniform outerseta, I = Enp_3 P_2 with spiniform terminal- and outerseta, J = P_5, P_6 and gen. seg. of male.

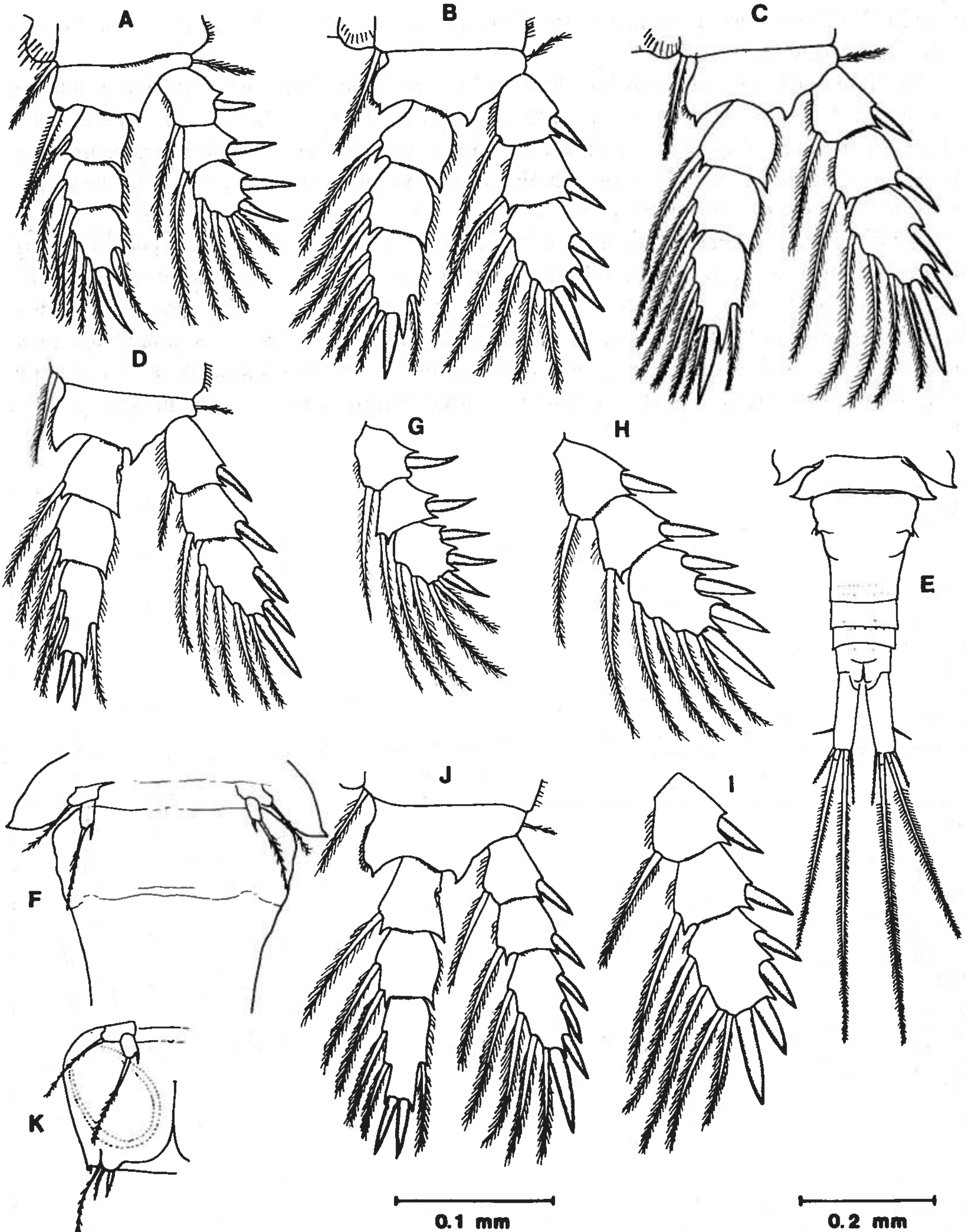

Fig. 3. *Acanthocyclops vernalis* (Fischer) from a rock pool: Tvärminne Zoological Station. A—D = P_1—P_4 of a female with normal number of spines on Exp_3, E = Abd. of female, dorsal view, F = P_5 and gen. reg. of female, G—I = Exp P_1—P_3 of a female with anomalous number of spines, J = ditto P_4, K = P_5, P_6 and gen. seg. of male.

$(r=0.65, P<0.001)$, but a negative correlation was found with the biomass of diatoms and with *Tintinnopsis tubulosa.*

The abundance of cyclopoids has decreased in Laajalahti since 1975—1976 and averages now about 1/4—1/2 of what it was at the beginning of the 1970s (Fig. 4). This decrease paralleled the diminished loading of sewage discharged into the Laajalahti area resulting in decreased phosphorus concentration and phytoplankton biomass in the water; also the greater diversity of plankton species indicated improved water conditions (Pesonen 1977).

In Vanhankaupunginselkä the annual variations have been marked also in the number of the cyclopoids as in the other hydro-biological properties (Fig. 4). The maxima of cyclopoids were about 200 ind./dm³ in 1969—1971 but increased later up to five fold. Also the loading by sewage discharged to the bay has increased during this period. The exceptionally low maximum in 1975 may be due partly to the low maximum of the water temperature. The maxima of cyclopoids coincided with the maximum of water temperature in Vanhankaupunginselkä

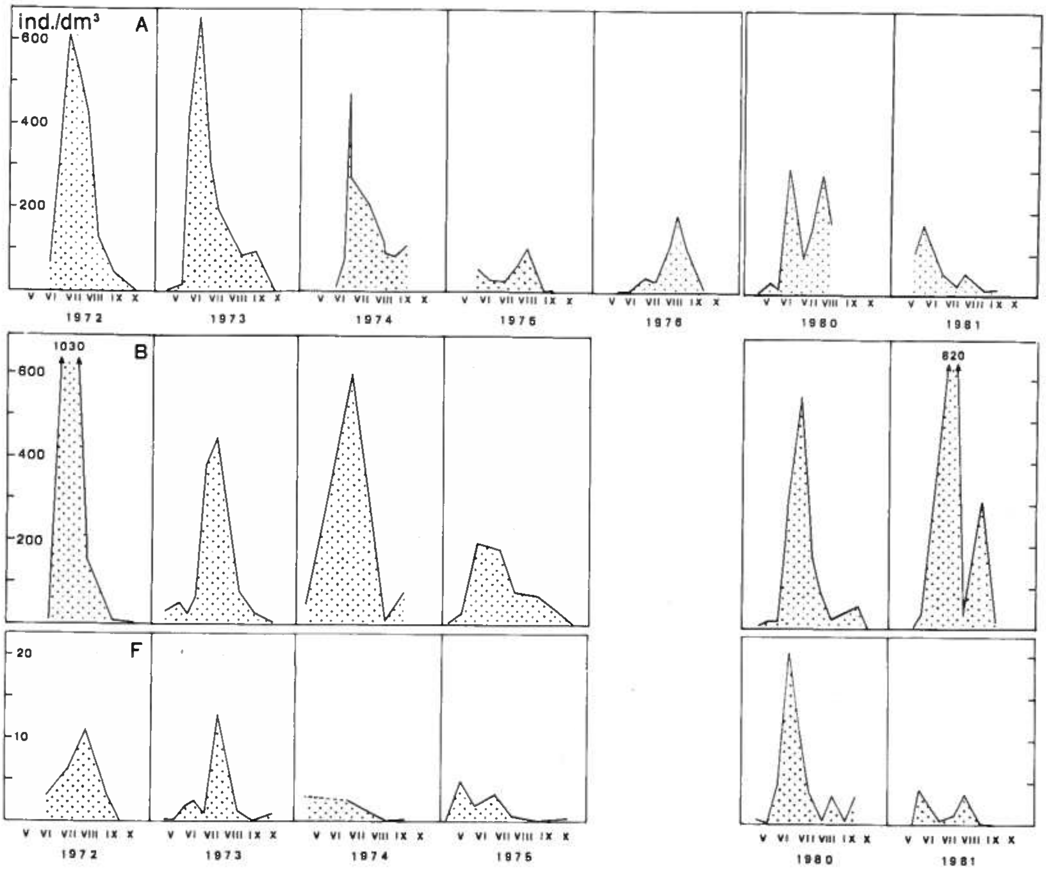

Fig. 4. The number of all developmental stages of cyclopoids (ind./dm³) during May—October 1972—1976 and 1980—1981 in Laajalahti (A), Vanhankaupunginselkä (B) and Vartiokylänlahti (F) (the whole water column).

TABLE 1. Relation between the number of cyclopoids (majority Acanthocyclops robustus) (means of June—September) and some independent variables (annual means) on ln-transformed data in Laajalahti in 1969—76 and 1980—81.

Correlation coefficients

variable	1	2	3
1. Cyclopoida (all developm. stages), ln (ind./dm³)			
2. Phytoplankton biomass, ln (mg/dm³)	0.829 **		
3. Phosphorus, ln (mg/dm³)	0.800 **	0.857 **	
4. Salinity, ln (‰)	—0.608	—0.281	—0.480

Multiple regression analysis

$Y = 5.38 - 3.81x_1 + 1.29x_2$

coefficient of determination $(R^2) = 0.841$

coefficient of multiple correlation = 0.917 **

standard error of estimate 0.34

Y = Cyclopoida, ln (ind./dm³)

x_1 = Salinity, ln (‰), annual means

x_2 = Phytoplankton biomass, ln (mg/dm³), means of May—October

risk levels: * = $P<0.05$, ** = $P<0.01$

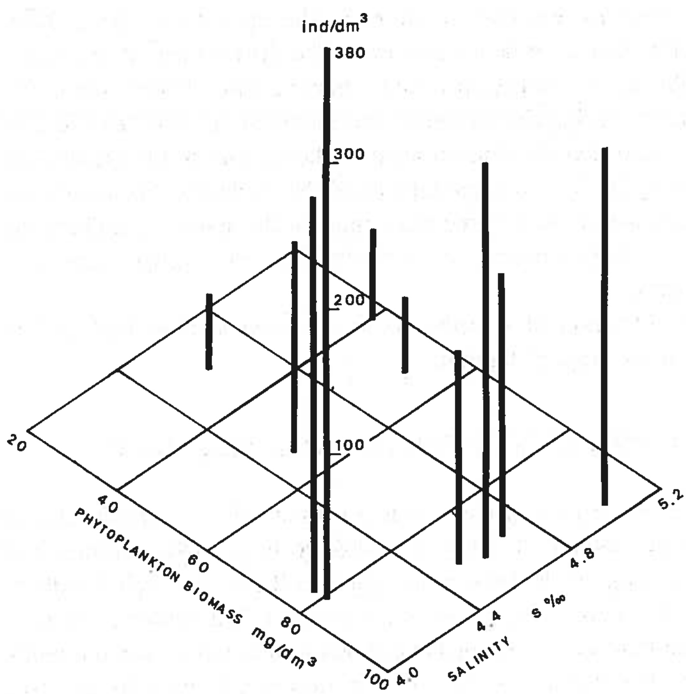

Fig. 5. The relation between the number of cyclopoids (all developmental stages) (means of June—September) the phytoplankton biomass (May—October) and salinity annual means in 1969—1976 and 1980—1981 in Laajalahti.

but not in Laajalahti. It is possible, however, that the sampling frequency used (usually every second week) was not sufficient to record the rapid variations in both hydrographical and biological factors.

In Vartiokylänlahti (Fig. 1 F), which is the least eutrophicated of the large bays around Helsinki, the number of cyclopoids has been very small and *Daphnia cucullata* dominate in summer.

To explain the annual variation in the abundance of cyclopoids, the environmental factors studied were: salinity, phosphorus concentration, primary production, chlorophyll *a* and phytoplankton biomass. In Laajalahti phytoplankton biomass had the highest positive correlation ($r=0.83$) with cyclopoids (Table 1).

According to multiple regression analysis, 84 % of the annual variation in the number of cyclopoids in Laajalahti could be explained by variations in salinity and phytoplankton biomass combined (Table 1, Fig. 5). The additional reduction in the sum of squares due to salinity was significant at a risk level lower than 5 %. The phosphorus concentration in this equation, replacing the phytoplankton biomass, gave nearly as high a coefficient of determination.

In Vanhankaupunginselkä, on the other hand, these parameters (or any combination of variables) were not found to have any significant effect on the annual variation of cyclopoids. Predation may often be the most decisive factor in zooplankton distribution.

The surprisingly strong invasion of *A. robustus* into the plankton of the eutrophicated bays of Helsinki sea area resembles very much a similar invasion in the eastern part of Bodensee (Lake Constance), where the maximum of copepodids and adults is up to 190 000 ind./m^2 (Einsle 1977). In Bodensee, *A. robustus* was known earlier in the littoral (cf. Kiefer 1963, 1973), whereas in our study area it seemed to be a newcomer. The distribution of the major part of the population of *A. robustus* in a restricted zone is characteristic of both areas. The occasional high proportion of males during the seasonal successions of *A. robustus* was also noted in both areas. The low sex ratio (females/males) seems to be typical to this species also according to the study of Vijverberg (1977) in a small lake in the Netherlands. The reason for such a mass occurrence of *A. robustus* in these three areas may be the same: eutrophication with optimal nutritional conditions, high amounts of phytoplankton for younger stages and ciliates and rotifers for older stages.

In the Helsinki sea area the restriction of *A. robustus* to the inner shallow bays of low salinity may be a consequence of its original habitat.

WHAT IS THE ORIGIN OF *A. ROBUSTUS* IN THE HELSINKI SEA AREA?

Because of its "setosus" form, *A. robustus* may have been confused with *A. vernalis* also in other previous papers published in Finland. *A. vernalis* seemed to be a fairly common and widely distributed species in rock pools of the Finnish archipelago (Levander 1900, Lindberg 1944). To confirm the point in this study, some cyclopoid samples taken earlier from rock pools in the archipelago of SW Finland were examined and it was found that *A. vernalis* really is very common, especially in smaller rock pools. *A. robustus*, however, belongs to the same fauna at the same time. In one sample (preserved in the Zoological Museum) taken on 22 June, 1950 from a rock pool (Dragsfjärd, Jungfruholm, Fig. 1) *A. robustus* abounded among the two limnic species *Daphnia pulex* and *Scapholeberis mucronata*.

This discovery justifies our assumption that *A. robustus* is a widespred species in the Finnish archipelago, even in the environment of Helsinki. Further, *A. robustus* may have been transported by nesting water birds from rock pools to the bay areas of Helsinki.

It would be worth while investigating what mechanism caused such an intense invasion of *A. robustus* into the Helsinki sea area during the late 1950s and the 1960s.

Acknowledgements

We wish to express our sincere thanks to Dr Heikki Salemaa, (Department of Genetics, University of Helsinki) for the kindly determination of chromosomes and the Zoological Museum (University of Helsinki) for providing material for the study. We are also grateful to Mrs. Gillian Häkli for correcting the English.

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LANDSAT CLASSIFICATION OF THE COASTAL WATER AREAS OF THE BOTHNIAN BAY OFF OULU. A PILOT STUDY.

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ABSTRACT

The computer-aided processing of Landsat MSS data offers a useful tool for coastal sea area classification and control by affording the capability of generalizing and mapping the distribution and character of certain types of sea areas over large regions by means of reflected radiation intensities.

The Landsat MSS data 206-14-790715 in CCT form over the coastal sea area of the Bothnian Bay off Oulu was classified into eight classes which where defined by their spectral reflectances. The open sea classes were characterized by spectral differences which are mainly caused by differences in water turbity or in water depth. Although the coastal shallow water areas were found to be defined by spectral changes caused by water depth, bottom quality, vegetation, and water quality there is still a need for quantitative data on how different biological, physical and chemical variables change the reflected spectrum.

INTRODUCTION

This research deals with the coastal sea area of the northernmost part of the Baltic Sea, the Bothnian Bay off Oulu. Most of the area is influenced by river and waste water flowing from the coast (Alasaarela & Myllymaa 1978, Alasaarela 1980). The sea area is mostly shallow but there is a long depression extending from the open sea close to the mouth of the river Oulujoki thus allowing the dilution of river discharges (Alasaarela 1978). The portion of the river water is especially important at the head of the Liminganlahti Bay where several small brown-coloured rivers discharge.

The phosphorus concentration and thus also the primary production of the Bothnian Bay is very low (Meskus 1976). The nutrient excess caused by river discharges and waste water loads from industrial activities and communities (Alasaarela 1979) may, however, cause at least local increase in productivity. The proportion of the river water may correlate with the depth configuration of the area (Alasaarela 1978). The highest chlorophyll a concentrations are found in open water areas between the island Hailuoto and the mainland at the site of the Liminganlahti Bay and between 5 to 10 km from the mouth of the river Oulujoki (Alasaarela 1979).

The open water area between islands close to the coast is characterized by variable open sea and coastal water phenomena. The nutrient amount, transparency and salinity depend on the relative importance of currents, river and waste water discharges and on the effectivity of the dilution and concentration of different water components (Alasaarela 1978).

METHOD

Landsat-2 satellite has a sun-synchronous near-polar orbit at an altitude of approximately 900 km. On board it has the multispectral scanner (MSS) imaging system registering and transmiting the line-scanned data of a 185×185 km^2 area with picture elements (pixels) of about 5000 m^2 simultaneously within four spectral bands:

Band 4	green, yellow	500— 600 nm
Band 5	red	600— 700 nm
Band 6	near-infrared	700— 800 nm
Band 7	near-infrared	800— 1100 nm.

Landsat-2 provides a theoretical 18-day complete coverage but this is rarely completely succesful due to cloudy weather. Because of the partial overlapping of the imagery of the following day there is the possibility under certain fortunate circumstances to observe also rapid changes in surface phenomena.

The Landsat imagery 206-14 of 15th of July, 1979 used in this work is available as either photographic products or in the form of computer compatible magnetic tape (CCT). The extraction of the Landsat data was made from this tape by using the Univac 1100/20 computer system and adjoining programs (Talvitie *et al.* 1979) of the University of Oulu which compute the necessary statistics for the reference fields chosen from the imagery. This computer-aided multispectral classification system recognizes all pixels with spectral properties similar to one of the reference areas thus providing as an output a map-like print of the studied area. All categories or classes of the print include such pixels which logically best coincide with one of the test fields.

Several reference fields were selected from the open sea off Oulu. All four bands were used in the classification. To determine which picture elements actually represented the open or deep sea those classes having a slightly rised band 7 values were excluded (cf. Arkimaa and Raitala 1981). The advantage of this procedure was the elimination of very shallow water, shoreline and vegetation effects. The band 7 was found to be perfect in determining the water areas because water effectively absorbs near-infrared wavelengths which are extensively reflected by green vegetation and different soils (Hoffer 1978). The other three wavelength bands then allow various water classes to be identified because they contain information from different depths and from different reflecting surfaces with different spectra.

RESULTS

SPECTRAL CHARACTERISTICS

The class defined by the acronym ODS (open deep sea class) is chosen to represent the open sea water off the island of Hailuoto, where no recognizable river water effects are to be found in summer (Alasaarela and Myllymaa 1978). The course of the spectrum is characterized by very low intensities within bands 6 and 7 (Fig 1). The reflected intensities increase towards the green band (band 4) which is typical for deep and clear waters (Specht *et al.* 1973). This ODS class did, however, not characterize all open sea areas and other reference fields were adopted for the shallows thus permitting a better classification result. The OSS (open shallow sea class) (Fig. 1) presents a combination of the spectra of the shallow open sea types. The mean value within band 7 is even slightly smaller than that of the ODS class but there is a clear increase of the OSS mean intensity already within the band 6 wavelengths which penetrate deeper into the water than those of band 7. The high intensity values of bands 4 and 5 indicate that the bottom is clearly visible through the shallow water. Only these two classes, ODS and OSS, still leave some open sea pixels unclassified: evidently owing to the spectral gap between them and to the small ground differences in depth, vegetation and wind/wave conditions. The unclassified pixels may also indicate the share of currents and dilution from the central and southern Bothnian Bay. The ODS class characterizes, however, in a satisfactory way the open sea reference water type for this study and the OSS class allows us to estimate the effect of the shallows on the spectrum.

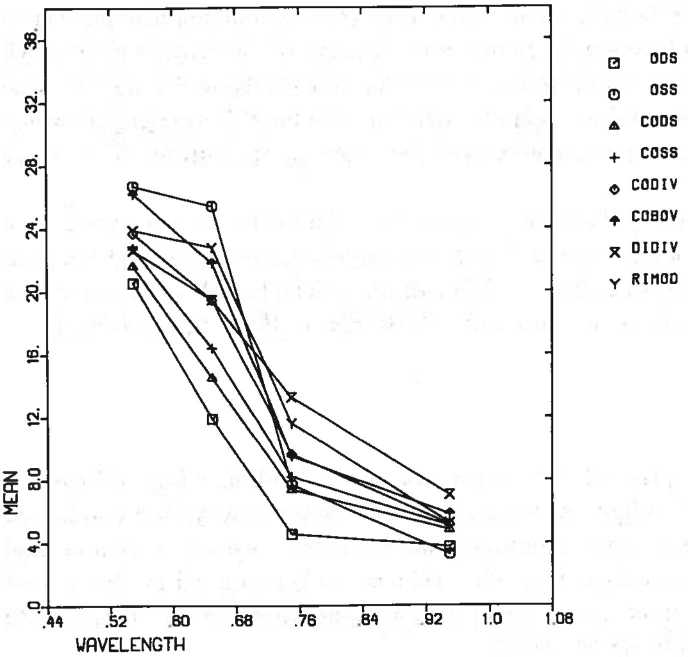

Fig. 1. Reflected intensity means measured by the Landsat MSS sensor within the chanels 4 through 7 for the test fields which are defined by the following acronyms: ODS (open deep sea), OSS (open shallow sea), CODS (coastal open deep sea), COSS (coastal open shallow sea), CODIV (coastal dilution & vegetation), COBOV (coastal bottom & vegetation), DIDIV (discharge dilution & vegetation), and RIMOD (river mouth discharge).

The reference field for the coastal deep sea (CODS) class was chosen from near the mid-channel of the harbour within the coastal head of the long depression and in the immediate vicinity of the mouth of the river Oulujoki. The depth is at least from eight to ten metres. The course of the spectrum (Fig. 1), when compared to that of the ODS class, indicates, that there is a better reflectance within every wavelength band thus revealing the more turbid nature (cf. Hoffer 1978) of this water type. A similar increase in the reflectance is also found within the coastal shallow sea class (COSS in Fig. 1), the reference field of which is situated at the entrance of the Liminganlahti Bay with a water depth of down to 8 metres. These two classes indicate some of the dilution of the coastal waters by open sea water but there may also be some effects caused by depth relations and the productivity brought about by nutrient increase upon approaching the discharging rivers.

The class titles "coastal dilution & vegetation" (CODIV), "river mouth disharge" (RIMOD) and "disharge dilution & vegetation" (DIDIV) denote lower hydrolittoral classes (Raitala and Arkimaa 1982) forming a series which is characterized by depth decrease and nutrient and humus increase from the CODIV class area to the DIDIV class area. A similar tendency to increase reflectivity values throughout the spectrum, as in the case of the CODS and COSS classes when compared with the ODS class, is clear (Fig. 1) and may be account for by the increase in the amount of turbid river waters, especially in the case of the Liminganlahti Bay. The course of their spectra within bands 4 and 5 also indicate the importance of the shallow water (cf. with the spectrum of the OSS class) — just a little higher reflectivities indicate lighter bottom soils and lower intensities indicate darker bottom soils in the case where the overall spectra of two classes is otherwise similar. The slight increase in band 7 or 6 intensity values (the DIDIV class, Fig. 1) may also indicate the effect of thin vegetation cover on the water surface (nympheides, helophytes and some rush growing units) or also just below the water surface (elodeides and isoetides), respectively, because the increasing chlorophyll content causes the increase of the near-infrared reflectivity and the band 6 data (obs. the RIMOD class) includes information from deeper water than the band 7 wavelengths which are absorbed within the uppermost few centrimetres of the water surface (Strong 1974, Lepley *et al.* 1975, Hoffer 1978).

The reference field of the coastal bottom & vegetation (COBOV) class is situated on a relatively shallow area near of the entrance of the bay Liminganlahti, where the light bottom slightly spotted by the low bottom vegetation is visible through the relatively clear water. The uppermost water layer is very similar to that of the COSS and CODIV classes (Fig. 1).

CLASSIFICATION PRINT

The multispectral classification print of the coastal sea of the Bothnian Bay off Oulu is displayed pixel by pixel in Fig. 2. Eight open sea and coastal water area types are indicated by matrix printer symbols. The shallow sublittoral zone with clear vegetation, bottom and shore-line indications in its spectrum (Raitala and Arkimaa 1982) is printed by the darkest symbol. The land areas and all other unclassified pixels with the spectrum not coinciding to that of any of the reference fields are left blank.

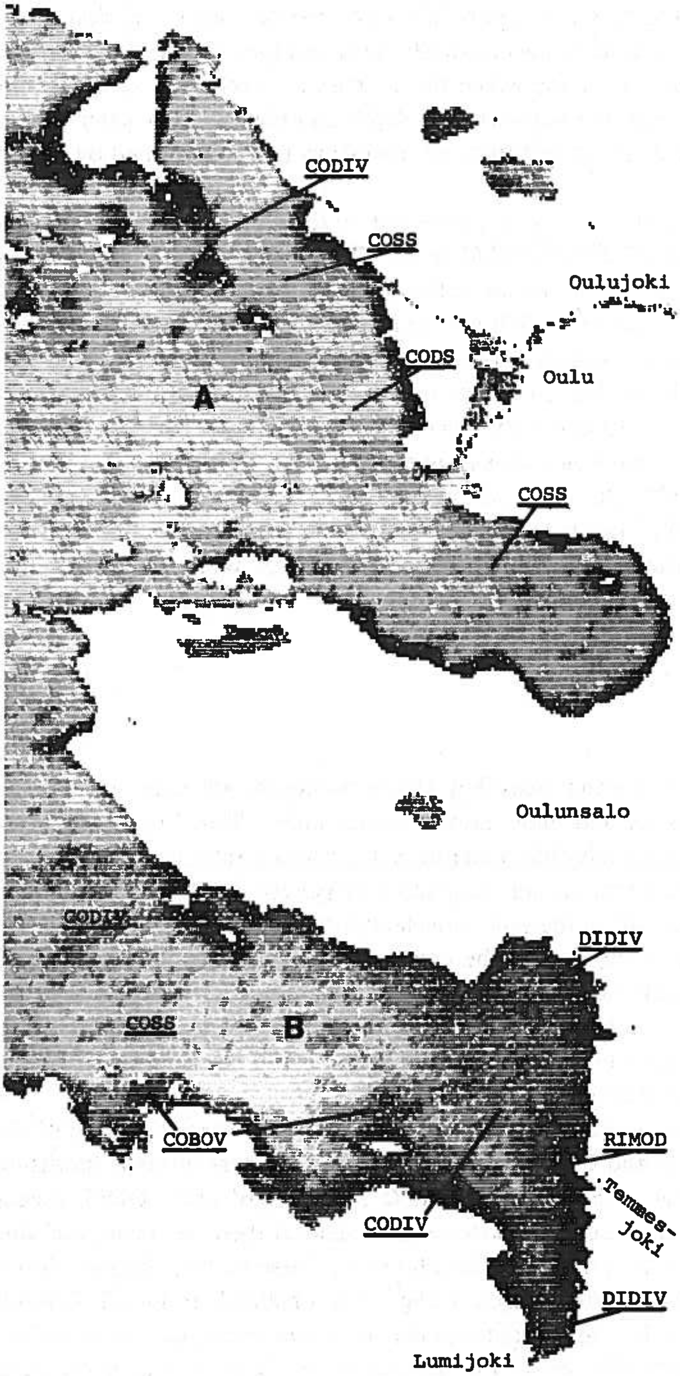

Fig. 2. Classification print for the coastal waters of the Bothnian Bay off Oulu (A) and over the Limingan-lahti Bay area (B). The print symbol indentifications are indicated by class acronyms (cf. Fig. 1).

The CODS class (Fig. 2) covers the sea area approximately over the long depression in the front of the mouth of the river Oulujoki. This relatively deep and long trench, extending to the open Bothnian Bay, is the channel along which the river waters streaming outwards and sea waters moving towards the coast mix together. The depth and the open sea water effects are thus involved in the river water effect and these are unable to be distinguished by means of the classification (Fig. 2).

Shallow parts of the open coastal sea are characterized by the COSS class (Fig. 2). This class also reveals the distribution of slightly turbid water. The CODIV class (Fig. 2) is then devoted to the coastal water shallows and to the still more turbid river waters of the rivers Temmesjoki (with a river mouth class RIMOD) and Lumijoki which are diluted by the sea water at the head of the bay Liminganlahti with some water vegetation.

The DIDIV and COBOV classes (Fig. 2) clearly map the vegetation and bottom effects within the near-shore areas which are still mostly covered by the open water surfaces. Because the near-infrared reflectance of turbid water with suspended sediments increases from that of clear waters (Bartolucci *et al.* 1977) the water within the COBOV class is more like the sea water and the water of the DIDIV class is mostly affected by the nutriens and humus of the river discharges. Because the transmittance of the water decreases when the amount of suspended sediments increases the COBOV class includes more information about bottom coverage.

DISCUSSION

The study of the spectra of different water areas (Fig. 1) accentuates the advantage of utilizing several wavelength bands to classify and map various surface units. "Pure" open sea water (for example the ODS class in this study) has a characteristic spectral reflectance of its own. Reflections from the water surface, bottom soil, vegetation, suspended and floating materials, chlorophyll and from different depths of the water are all important in changing the spectrum and give it the peculiar course. According to the course of the spectrum it is possible to evaluate the share of the most important water constituents which have left their fingerprints on the reflected radiation (cf. Lindell 1980, Arkimaa & Raitala 1981). Attention must, however, be paid to the point that every picture element may contain information of several surface units having different reflectivities and extent.

Several surface units may have quite similar reflectances within one special portion of the spectrum (for example the COSS and CODS classes throughout the near-infrared spectrum; the RIMOD and CODIV classes within bands 7 and 4; the COBOV and CODIV classes within band 6; and the DIDIV and CODIV classes within band 5) therefore being not able to be classified on images obtained in these wavelength bands. These surface units or classes are, however, easily qualitatively differentiated using data obtained from all Landsat multispectral scanner bands. Besides these qualitative classifications also quantitative evaluations should be developed (Lindell 1980) before this method is feasible to show its best advantages in surveying and interpreting the character of water areas in time and in place on a scale which is impossible in situ measurements and samplings.

The present study has probably indicated that multispectral Landsat data classification offers a new effective tool for water area surveying (cf. also Arkimaa & Raitala 1981, Kuittinen & Franssila 1981). In addition to the qualitative information there is also a growing need for precise quantitative knowledge of phenomena controlling the spectral reflectivity in sea.

Computer-aided data processing of the whole 185×185 km² image area provides quite convenient and low-cost classification possibilities to control sea areas theoretically on an every 18 day cycle or even in favorable circumstances over the course of three consecutive days.

Acknowledgements

Professor K.A. Hämeen-Anttila, Head of Department of Astronomy, University of Oulu, is acknowledged for supporting this study. The study was supported financially by the Foundation for Research of Natural Resources in Finland.

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MARINE WIND CHARACTERISTICS IN THE NORTHERN BALTIC SEA

WIND CHARACTERISTICS AT FINNISH AUTOMATIC MARINE WEATHER STATIONS IN THE NORTHERN BALTIC SEA

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ABSTRACT
The report underlines marine wind characteristics in the northern Baltic Sea. The data are primarily based on recent automatic marine weather stations (ODAS stations), which yield relevant data for the purposes above. Wind statistics are given and overall characteristics are discussed. Some features of gustiness are reported and, finally, comparisons of marine wind conditions with those on the coast are made.

1. INTRODUCTION

The demand for marine meteorological information has continuously increased not only in daily weather, sea ice and navigation safety surveys but also in atmospheric and oceanographic studies and in some aspects of utilisation of energy resources. Physically and statistically representative data and statistics for the above purposes in the Baltic Sea region are, however, astonishingly sparse. One of the main reasons is that most of the regular observations with modern instruments have been carried out in coastal or archipelago areas, and these are seldom representative of marine areas. In addition, the automatization of lighthouses and other navigation safety devices during the last decades has often left the most suitable marine observation sites unmanned. A significant improvement to the situation has been made since 1977 when the Finnish National Board of Navigation started to install automatic marine meteorological stations collecting versatile data in offshore open sea lighthouses.

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This study deals primarily with wind characteristics based on observations at four former stations (Table 1) in 1977—1982. Wind statistics are given and overall wind characteristics based on the data are discussed. Some features of gustiness are reported and, finally, observations of wind conditions at sea are compared with those made on the coast. Parts of this study have been published in a preliminary report by Laurila and Launiainen (1983).

2. DATA

The six automatic marine weather stations currently in operation are shown in Fig. 1 and in Table 1.

TABLE 1. Finnish automatic marine weather stations.

	Position		Year started
Kemi	65°23.0'N	24°06.0'E	1978
Ulkokalla	64°19.8'N	23°26.9'E	1978
Märket	60°18.1'N	19°08.2'E	1978
Kalbådagrund	59°59.2'N	25°36.2'E	1977
Rauma	61°08.9'N	21°10.1'E	1982
Bogskär	59°30.3'N	20°21.1'E	1982

Kemi is a caisson lighthouse in the northern Bothnian Bay over 40 km from the nearest coast. The wind is measured at the top of the lighthouse at 25 m above sea level and 0.7 m above a helicopter terrace.

Ulkokalla is a flat, treeless island (0.5×0.15 km) with a lighthouse and some old pilot buildings in the Bay of Bothnia, 18 km from the eastern coast. The wind is measured at about 16 m above sea level from a mast rising 4 m above the roof of a building.

Märket is a lighthouse on a rock between the Swedish mainland and the Åland archipelago. The wind is measured 21 m above the mean sea level and 2.5 m above the roof of the lighthouse.

Kalbådagrund is a caisson lighthouse on the northern coast of the Gulf of Finland, about 20 km from the archipelago. The wind is measured 32 m above mean sea level and 1.5 m above and a few metres from the side of a helicopter terrace.

Rauma is a caisson lighthouse in the eastern Bothnian Sea, 10 km from the coast. The wind is measured 24 m above sea level and 0.7 m above and 1.5 m from the side of a helicopter terrace.

Bogskär is a lighthouse on a rock in the northern Baltic Proper. The wind is measured at a height of 31 m, and 0.7 m above and 1.5 m from the side of a helicopter terrace.

For comparison, wind data (Meteorological Yearbooks of the Finnish Meteorological Institute) on several synoptic stations were also used.

2.2. MEASUREMENTS AND THE REFERENCE HEIGHT CORRECTION

Wind velocity is measured at the automatic weather stations using a light cup anemometer (Vaisala WAA 12) with an integration time of 2 seconds. Wind direction is measured with a wane (Vaisala WAV 12). Both quantities are measured at 2-second intervals.

The mean wind speed and direction of a 10-minutes' period are processed every three hours with the observational instrumentation system used (MIDAS 300 by Vaisala Co). They are then registered on magnetic tape and transmitted to land.

The maximum (gust) wind speed is the highest velocity (in 2s) observed during one 3-hour observation interval.

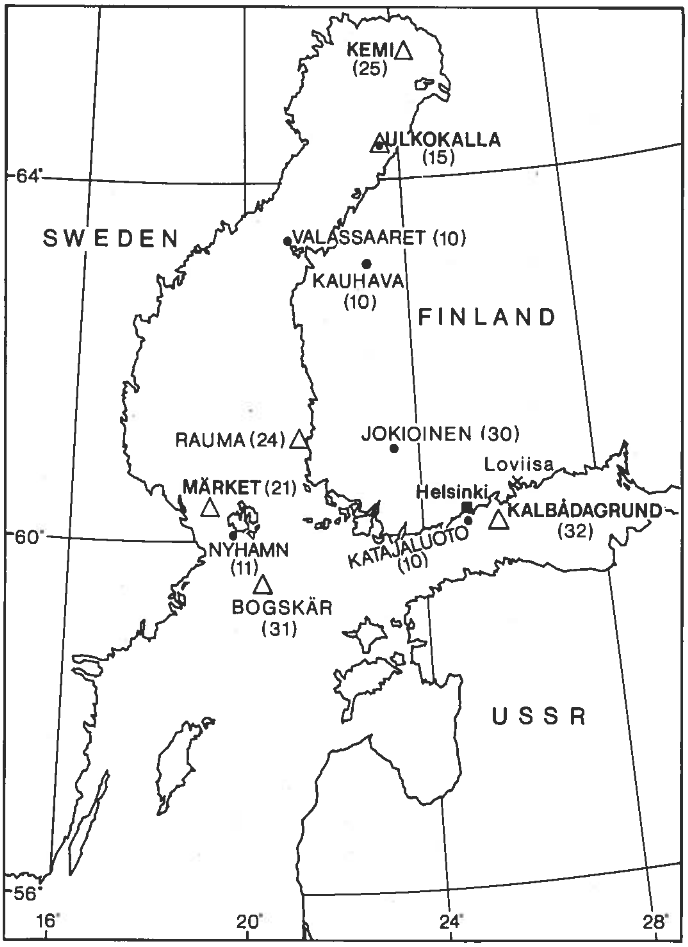

FIG. 1. Location of the Finnish automatic marine weather stations (Δ) and reference synoptic weather stations (●). The numbers in brackets indicate the observation heights: from sea level for (Δ) stations and from ground level for (●) stations.

The main purpose of the automatic marine weather stations is to provide data for synoptic meteorological service. Accordingly, requirements and maintenance of instrumentation at sea make precise calibration difficult and accuracy ambiguous; for practical reasons the wind sensors are changed yearly. However, the sensortype used has proved itself both rather stable and reliable in several studies.

All the results in this study refer to the height of the station in question; except in chapter 3.5.2, no height corrections were done. However, the wind speed may be estimated for any reference height in the surface (constant flux) layer, say, from the surface up to about 40—50 m, using the wind profile relationships based on the universal Monin-Obukhov similarity theory. Hence, the wind speed ratio between two measurement height yields

$$\frac{u_2}{u_1} = \frac{\ln \frac{z_2}{z_0} - \psi_M(\xi_2)}{\ln \frac{z_1}{z_0} - \psi_M(\xi_1)} \qquad (1)$$

where u_2/u_1 is the wind speed ratio between two reference heights of z_2 and z_1, z_0 is the roughness parameter characteristic of the surface, and $\psi_M(\xi_2)$ and $\psi_M(\xi_1)$ are the stability induced (universal function) corrections to the logarithmic wind profile. Universal functions are expressed in term of a stability parameter (ξ) describing the stability conditions in question.

For most practical studies, especially for statistical ones, the stability effect is of a second order of importance, or then stability conditions are unknown, in which case

$$\frac{u_2}{u_1} = \frac{\ln \frac{z_2}{z_0}}{\ln \frac{z_1}{z_0}} \qquad (2)$$

Table 2 gives the height corrections for estimating the wind speed at heights of 10 m, 50 m and 2 m using the automatic weather station data. For the roughness parameter, $z_0 = 1 \times 10^{-4}$ m was used, which corresponds to the drag coefficient of $C_{D10} = 1.3 \times 10^{-3}$ for the sea surface. In addition to the neutral-case corrections according to Eq. (2), examples of the corrections under diabatic conditions are also given.

Table 2 shows that for neutral and slightly unstable conditions, which dominate over the open sea in autumn and late summer, the height correction may be obtained from the logarithmic profile, and the statistical automatic weather station data can be compared with each other without any corrections for height. For precise case studies under stable conditions (early summer) information about stability is necessary.

The roughness parameter z_0 used in (1) and (2) for Table 2 was a constant one based on a "consensus" drag coefficient over the sea. However, because of "ln z_0" the height correction is rather insensitive to variations in the roughness parameter. For example, the use of wind dependent roughness parameters based on the commonly used drag coefficient formulae of Garratt (1977) or Wu (1980), give results which deviate from Table 2 by less than three per cent. For practical applications, the correction for height above the sea may be estimated for neutral conditions from

$$u_2/u_1 = \ln (10^4 \cdot z_2) / \ln (10^4 \cdot z_1) \tag{3}$$

where the subscribts refer to the velocities and heights (in m) of two measurement levels.

TABLE 2. Height corrections for estimating wind speed at referende heights of 10 m, 50 m and 2 m using automatic weather station data. The column "neutral" gives the correction according to the logarithmic wind profile (2). The "unstable example" corresponds to a situation in which the air temperature is 3°C cooler than the sea surface temperature and the wind speed at the station height is around 7 ms^{-1}. In the "stable example" the air temperature is 3°C warmer than the sea surface; otherwise the conditions are the same. (The examples for non-neutral cases were done by an iteration method, cf. Launiainen, 1979.)

		"neutral"			"unstable ex"		"stable ex"	
Station	z/m	u_{10}/u_z	u_{50}/u_z	u_2/u_z	u_{10}/u_z	u_{50}/u_z	u_{10}/u_z	u_{50}/u_z
Kemi	25	0.92	1.05	0.80	0.95	1.03	0.79	1.30
Ulkokalla	16	0.96	1.10	0.83	0.97	1.06	0.90	1.44
Märket	21	0.93	1.07	0.81	0.96	1.04	0.83	1.36
Kalbådagrund	32	0.91	1.04	0.78	0.94	1.02	0.71	1.22
Rauma	24	0.92	1.05	0.80	0.95	1.03	0.80	1.32
Bogskär	31	0.91	1.04	0.78	0.94	1.02	0.72	1.23

3. WIND CHARACTERISTICS

The available wind statistics during the observation period 1977—1982 are given as tabulated on a monthly basis in the Appendix 2. The tables give the frequency distributions of mean and maximum wind speeds as well as the monthly means and standard deviations, the observed maximum values of mean and momentary (maximum) wind speeds and, the data coverage in percentages. The wind characteristics are discussed in more detail below.

3.1. AVERAGE WIND CONDITIONS, MEAN ANNUAL COURSE OF WIND SPEED

Figure 2 gives the available wind speed statistics for Kemi, Märket and Kalbådagrund in the form of monthly means. The results indicate an apparent annual course, the early summer being the calmest and the late autumn the windiest season. The first harmonics fitted to the data are given. For reference, Fig. 2 also gives the first harmonics fitted to the long-period data from the two synoptic stations, Ulkokalla and Nyhamn. The result according to which the mean annual course of the wind over the sea may be approximated reasonably well by a harmonic wave is further shown in Figs. 3 and 10.

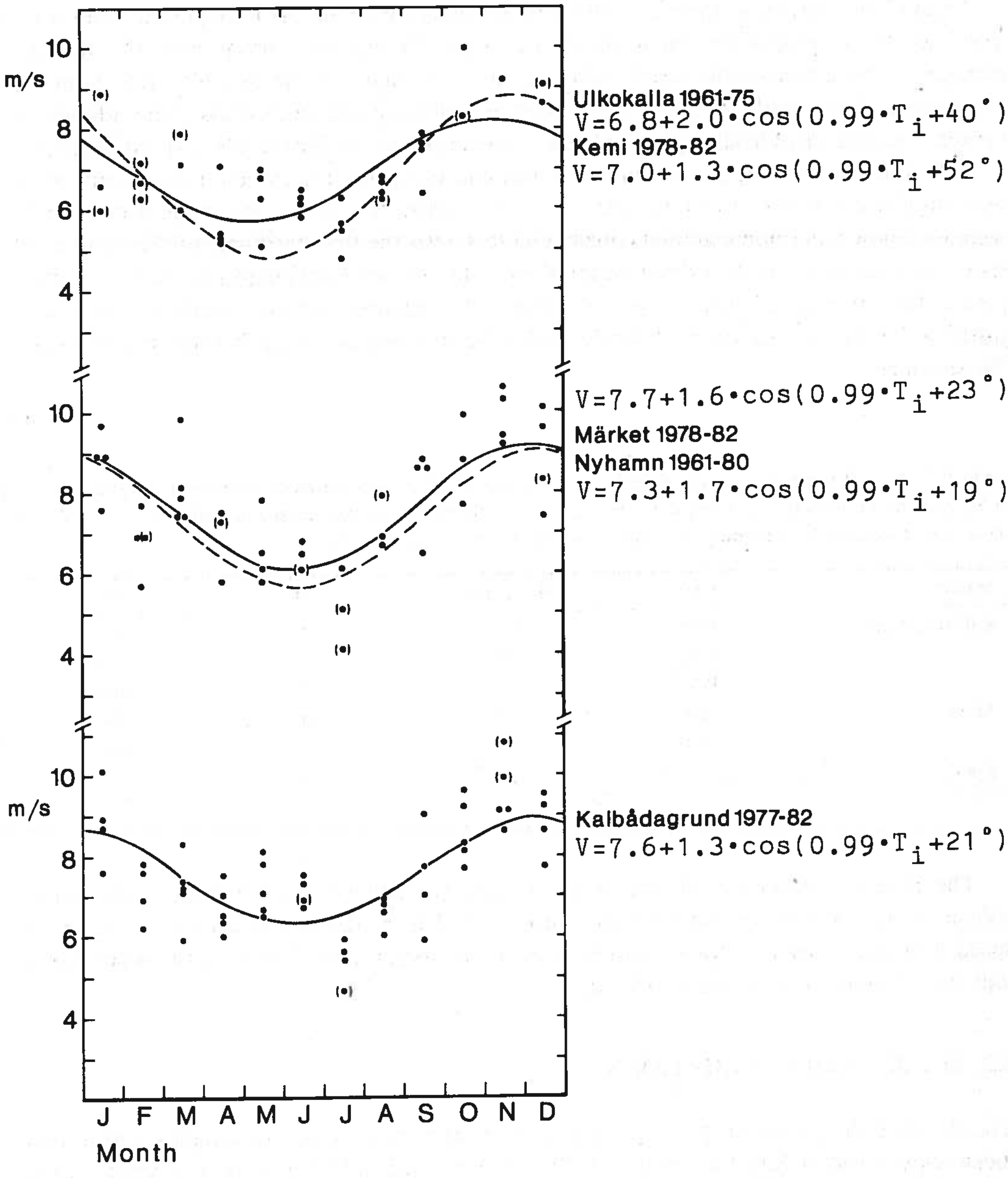

FIG. 2. Monthly wind speed averages at Kemi, Märket and Kalbådagrund in 1977—1982. The symbol indicates the data coverage; ● over 80 % of observations available (●) over 50 % of observations available. The continuous curves represent the first harmonics fitted to the long-period data from the two reference stations; Ulkokalla and Nyhamn (cf. Fig. 1). The harmonic expressions are given in m/s. The quantity T_i is the order of the day of the year.

Figure 2 indicates that there is rather little difference between the long-period mean wind speed conditions in different open sea areas and that the standard deviation of the monthly averages between consecutive years is around 15 %. At Kemi, in the Bothnian Bay, however, the average wind speeds are 10 % lower than at Kalbådagrund and Märket (the differences between measurement heights given in Table 2 do not play a significant role in this difference).

As indicated in Table 3, the annual means and especially the standard deviations differ only slightly between consecutive years. Like the means, the variances (standard deviations) seem to follow a harmonic annual course. Figure 3 gives the first harmonic of the mean wind speed and variance fitted to the data for Kemi, Märket and Kalbådagrund and to the long-period data from Ulkokalla, in which the more representative statistics reduce scattering and justify a "harmonic" approach. There is no significant phase difference between the mean and the variance.

TABLE 3. Annual means and standard deviations of the mean wind speed based on three-hour observations (N) at Kalbådagrund and Märket. Kemi data coverage is insufficient for calculating the annual means. The overall mean was calculated by weighting the data according to the annual course.

Station	Year	Mean/ms^{-1}	SD	N
Kalbådagrund	1978	7.6	3.7	2512
	1979	7.8	3.8	2872
	1980	7.0	3.7	2899
Märket	1979	7.7	3.6	2498
	1980	7.3	3.8	2805
Kemi	1978—1982	7.0	3.6	

The monthly meán wind velocity components are presented in the Appendix 1. The annual course of the monthly resultant vector is not so evident as the annual course of the scalar speed. However, strong winds in autumn provide the major contribution to the yearly resultant vector, pointing towards northeast.

3.2. SHORT-PERIOD VARIATIONS

The standard deviations in the Appendix 2 give a view of short-period variations. The daily mean wind speed at Kalbådagrund in 1979 and 1980 is given in Fig. 4 as an example of the characteristic day-to-day variations in all the stations. Fig. 4 indicates that the short period fluctuations are decisive; thus e.g. the statistical result above, according to which the winds are at their lowest and fluctuations are at their smallest in summer (a sinusoidal yearly course), is not so apparent from one-year results only.

The data do not give evidence of diurnal scalar wind variations at Kalbådagrund and Märket. However, a diurnal course exists at Kemi in summer. By and large, wind speed is at a minimum in the afternoon and at a maximum at night. The amplitude of the monthly means is of the order of 1 m/s. It is assumed that these velocity variations are caused by the

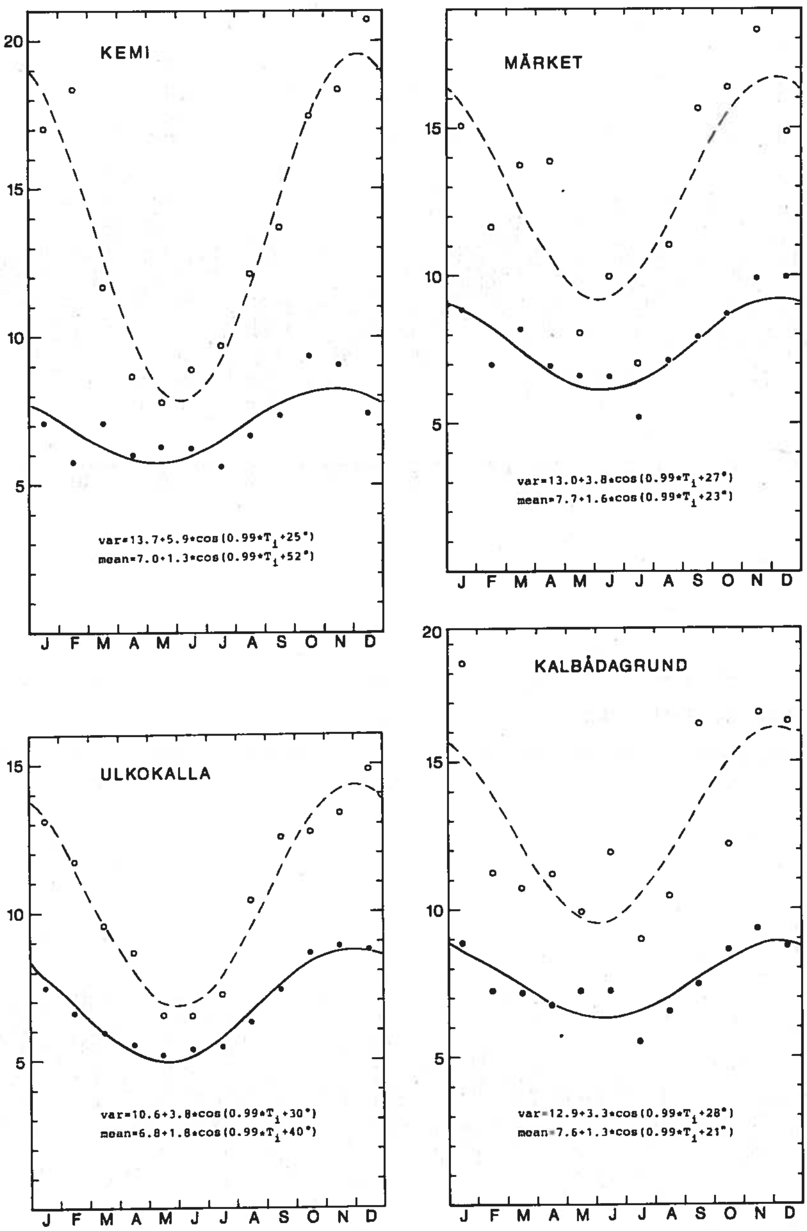

FIG. 3. Mean monthly averages and variances of wind speed (based on three-hour observations) at Kemi, Märket and Kalbådagrund in 1977—1982 and at Ulkokalla in 1959—1973. The continuous and broken curves represent the first harmonics fitted to the monthly means and variances, respectively. T_i is the order of the day of the year.

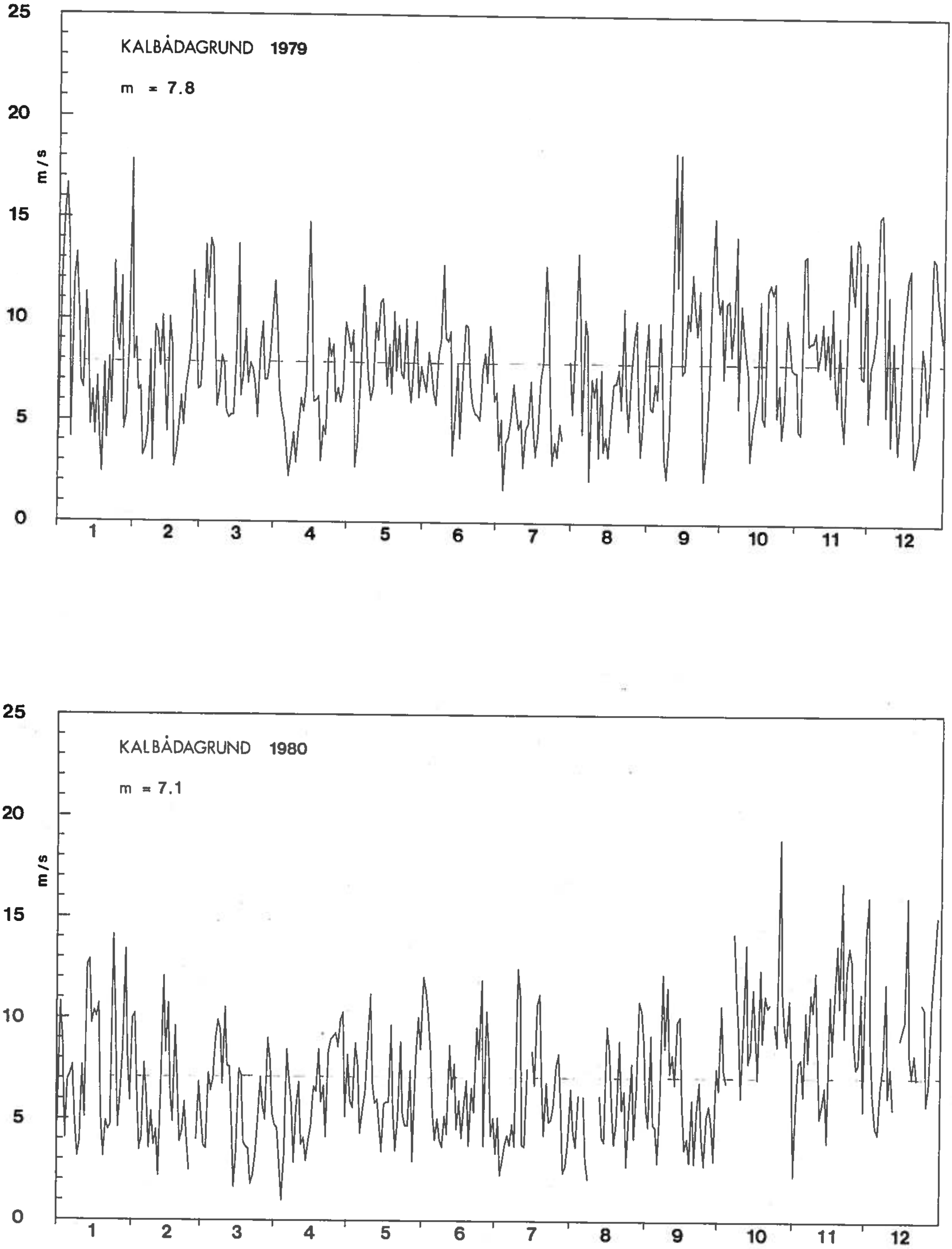

FIG. 4. Daily mean wind speed at Kalbådagrund in 1979 and 1980.

advection of diurnal temperature waves from the Finnish coast. In the afternoon warmer air is advected over the sea, which leads to increased stratification and reduced surface wind speed.

3.3. DIRECTIONAL CHARACTERISTICS

The wind direction distributions in the northern Baltic Sea reflect general atmospheric circulation (Figs 5 to 7). Synoptic disturbances are the major determining process in autumn and winter, when strong southwest winds predominate, although all directions occur frequently. Synoptic scale circulation is weaker in spring and summer, and consequently, mesoscale roughness and thermal conditions seem to play a more important role, as revealed in the adjustment of directional distribution parallel to the sea recipient.

At Kalbådagrund the most common wind directions in spring and summer are from west-southwest and east, parallel to the Gulf of Finland (Figs. 5F and 6E). In summer the wind is from directions 225°—270° a quarter of the time. Typically, gale force winds are from west-southwest and east throughout the year.

At Märket the most common directions in spring and summer are from north and south-southeast (Figs. 5D and 6C), parallel to the Southern Quark between the Gulf of Bothnia and the Baltic Proper, from the sector 120°—180°. In summer the wind is from 135°—180° 27 % of the time and from 315°—45° 33 % of the time. Gales are usually from north-northwest and south.

The Bothnian Bay opens to the southwest from Kemi and in all seasons the most common wind direction is from southwest although north-northeasterly winds are also frequent. In summer, winds are from between 200°and 250° 20 % of the time. Gales are typically from southwest and northeast.

For comparison of two consecutive years, Fig. 7 gives the annual directional distribution at Kalbådagrund in 1979 and 1980.

3.4. MAXIMUM TO MEAN WIND SPEED RELATION, GUSTINESS

Maximum wind speed (gust) is measured at the Finnish automatic marine weather stations as the greatest velocity of an integration time of 2 seconds during a synoptic three-hour interval.

As expected on a theoretical basis and indicated by experimental studies, a first order estimate of the maximum gust under specific conditions can be obtained from the relationship between gust and mean wind, e.g. as

$$u_{max} = a + bu_{mean} \tag{4}$$

where the experimental coefficients a and b characterize gustiness, which depends primarily

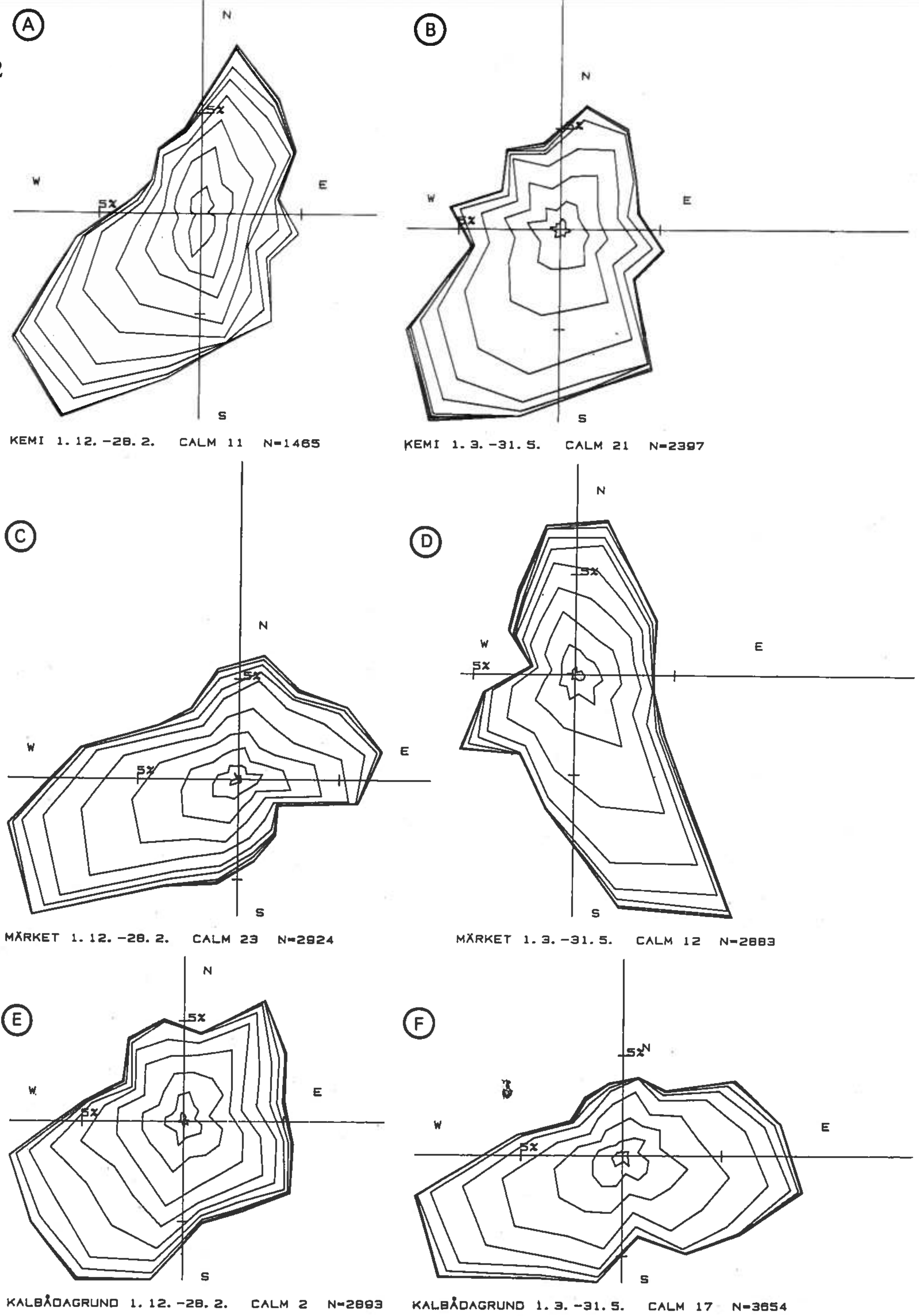

FIG. 5. Distributions of wind direction at Kemi, Märket and Kalbådagrund in winter and spring. Contours are at 2 m/s intervals. In each direction class the distance between the contours gives the frequency distribution and the distance from origin gives the cumulative percentage. The amount of calms and the total number of observations are also shown.

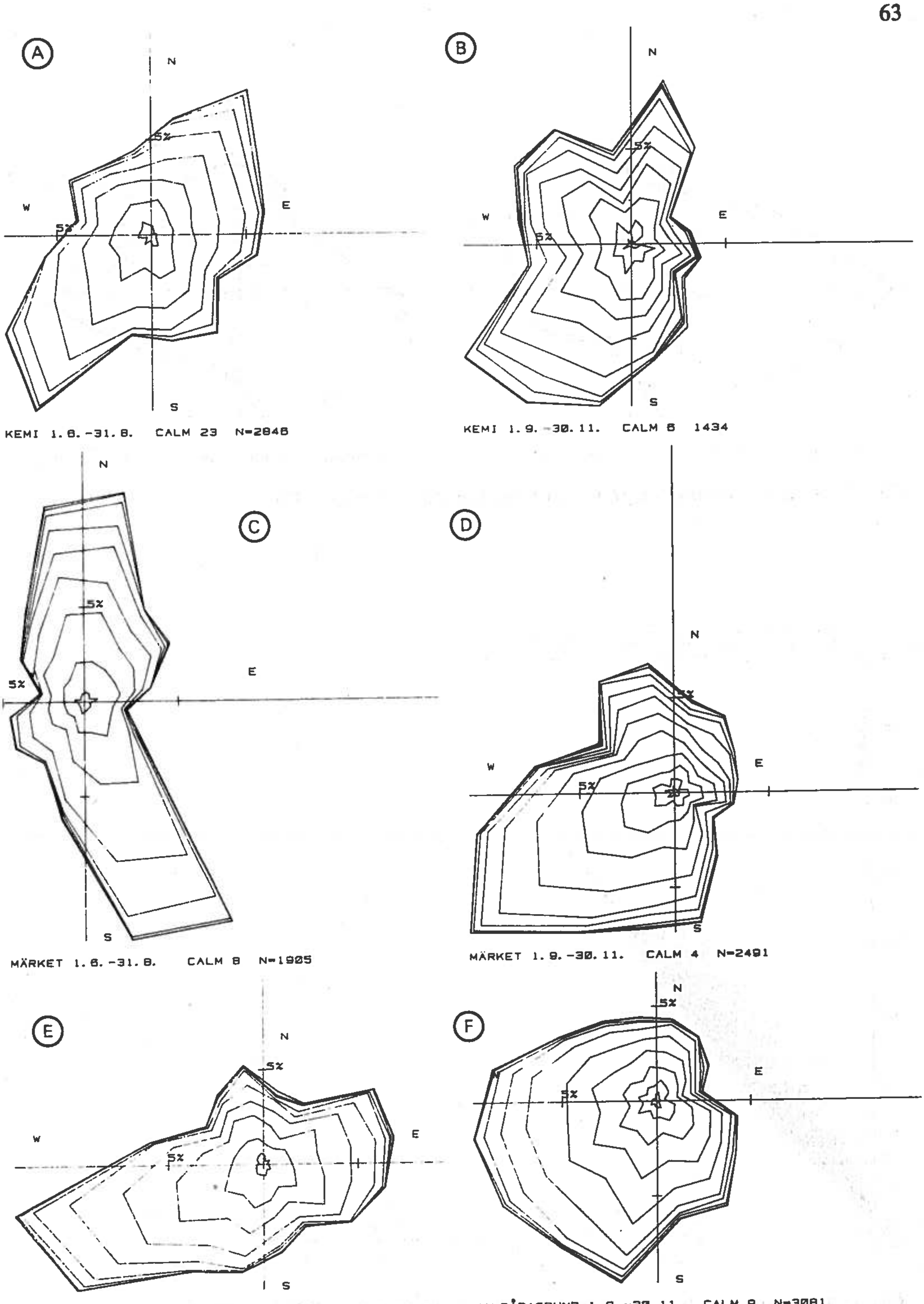

FIG. 6. Directional distribution of wind for summer and autumn.

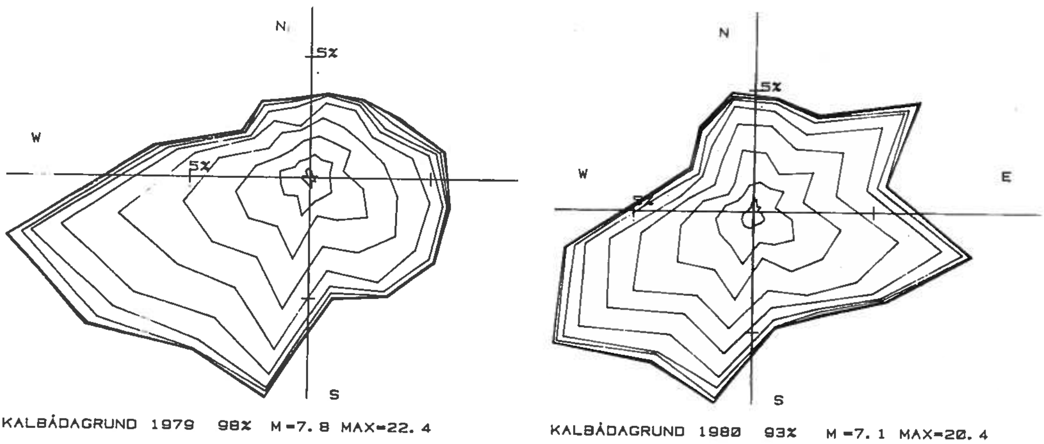

FIG. 7. Directional distribution of wind at Kalbådagrund in 1979 and 1980.

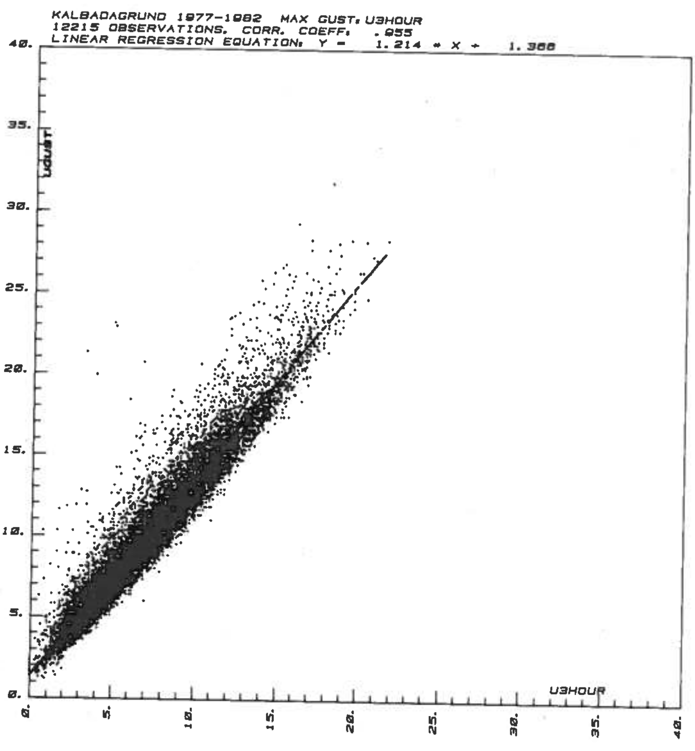

FIG. 8. Maximum versus mean wind speed at Kalbådagrund in 1977—1982. (For definition of the maximum and mean wind speed, see text.)

on surface roughness, stability and height. The length of the period of measuring of gust and averaging period of mean wind speed also affect the numerical values.

Figure 8 shows the ratio of maximum to mean wind at Kalbådagrund in 1977—1982. This shows an apparent relationship, which may be roughly approximated as a linera fit, especially for low and moderate wind speeds. For u_{max} (of 2s) a linear fit yields

Kalbådagrund: $$u_{max} = 1.21\ \overline{u}_{3h} + 1.37\ m/s \qquad r = 0.955 \tag{5}$$

Kemi: $$u_{max} = 1.23\ \overline{u}_{3h} + 1.21\ m/s \qquad r = 0.951 \tag{6}$$

There were 12,219 data sets in the former and 8,034 in the latter. The results for Märket are very similar to those for Kalbådagrund.

Unfortunately, because the simultaneous maximum and mean, wind velocities could not be measured. The mean velocity was estimated as an average of the 10 min means at the beginning and end of a three-hour period.

3.5 WIND VELOCITY DISTRIBUTIONS

3.5.1 Frequency distributions and wind power density

Frequency distributions of the mean and maximum wind speeds at Kalbådagrund and Märket in June and December are given in Fig. 9. The wind velocity follows a continuous distribution which may be approximated using theoretical probability functions, such as the Gamma distribution or the Weibull distribution. In our data, the statistics of the mean wind, are described somewhat better by the Weibull distribution (fitted to the data by the least square method; e.g. Justus et al. 1976). The probability density function of the Weibull distribution is given as

$$P(x) = (k/c)\ (x/c)^{k-1} \exp\left[-(x/c)^k\right] \tag{7}$$

where c is the scaling parameter and k the shape coefficient.

Fig. 9 shows that the Weibull distribution is well representative of open sea winds, owing to the lower frequency of calm and light winds at sea than under inland conditions.

The mean monthly Weibull parameters are listed in Table 4. These are larger than those usually observed over land. Shape factor, which is inversely proportional to the variance, suggests that wind speed variations are less marked over the open sea than over land, i.e. the frequency distribution is "narrower". The shape factor k is at its smallest in spring and summer and at its greatest in autumn, being, for example, k = 1.82 in July and k = 2.86 in October, at Kalbådagrund.

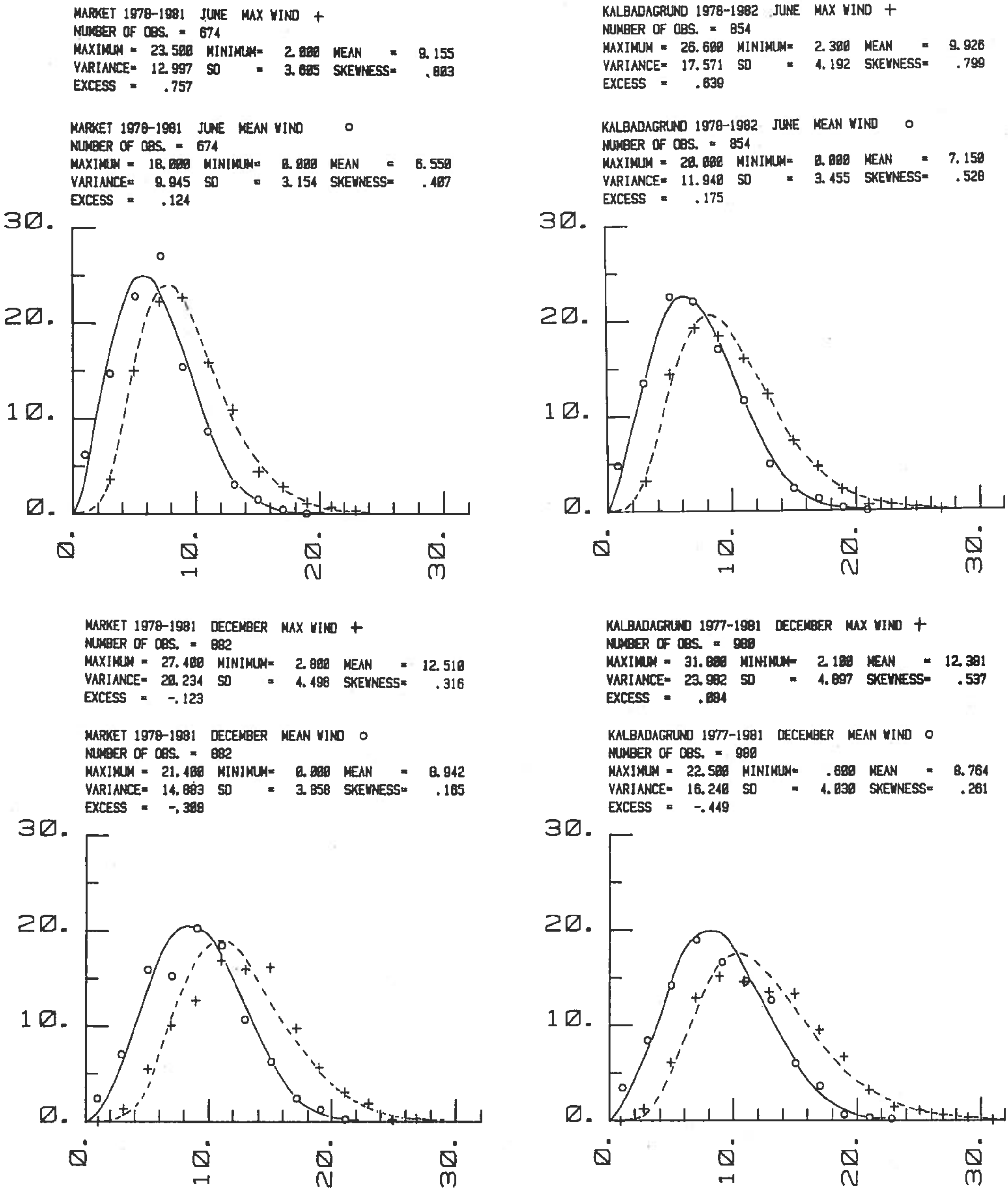

FIG. 9. Frequency distributions of wind velocity for Märket and Kalbådagrund in June and December. Distributions are given for a ten-minute mean velocity with a Weibull distribution function fit (continuous) and for maximum wind distributions with a Gamma distribution function fit (dashed). Fitting parameters are listed in Tables 4 and 5.

The distribution functions provide a useful tool for estimating gale force winds and storms and even maximum winds of different periods (Hedegaard 1982). A theoretical function fits well as is revealed by the fact that the estimates of the mean potential wind power density, proportional to the third power of the wind speed, differed less than 4 % for any month and station, when calculated directly from observations or from the Weibull distribution fit. The annual cycle (proportional to u^3) of the mean power density is similar to that of the mean wind. For example, at Kalbådagrund the mean power density in November is 3.8 times larger than that in July (cf. Table 4).

TABLE 4. Mean monthly statistics of the 10 min. mean wind. Mean ($\overline{u}$) and standard deviation (SD), average of the third power ($\overline{u^3}$) and the Weibull parameters c and k are listed.

	Kemi					Märket					Kalbådagrund				
	$\overline{u}$	SD	$\overline{u^3}$	c	k	$\overline{u}$	SD	$\overline{u^3}$	c	k	$\overline{u}$	SD	$\overline{u^3}$	c	k
JAN	7.1	4.1	758	8.2	1.95	8.8	3.9	1098	10.1	2.60	8.9	4.3	1206	10.2	2.35
FEB	5.8	4.3	553	6.6	1.50	7.0	3.4	598	7.9	2.17	7.2	3.4	643	8.1	2.21
MAR	7.0	3.4	615	7.9	2.14	8.2	3.7	915	9.1	2.22	7.2	3.3	619	8.1	2.26
APR	6.0	2.9	386	6.8	2.16	6.9	3.7	661	7.8	1.90	6.7	3.4	543	7.7	2.24
MAY	6.3	2.8	399	7.2	2.59	6.6	2.8	450	7.5	2.56	7.2	3.2	594	8.4	2.80
JUN	6.2	3.0	423	7.1	2.23	6.6	3.2	498	7.5	2.24	7.2	3.5	656	8.2	2.20
JUL	5.6	3.1	354	6.4	1.93	5.2	2.7	260	5.9	2.07	5.5	3.0	345	6.1	1.82
AUG	6.6	3.4	524	7.5	2.15	7.1	3.3	608	8.1	2.34	6.5	3.2	495	7.5	2.28
SEP	7.3	3.7	715	8.3	2.12	7.9	4.0	910	8.8	2.00	7.5	4.0	813	8.6	2.06
OCT	9.3	4.2	1308	10.8	2.62	8.7	4.1	1098	9.9	2.41	8.6	3.5	962	9.8	2.86
NOV	9.0	4.3	1289	10.1	2.16	9.9	4.3	1548	11.2	2.51	9.4	4.1	1294	10.7	2.68
DEC	7.4	4.5	907	8.5	1.80	9.0	3.9	1131	10.3	2.66	8.7	4.1	1116	10.0	2.43

TABLE 5. Mean monthly statistics of the maximum wind. Mean ($\overline{u}$) and standard deviation (SD), Gamma distribution parameters a and r, and Weibull parameters c and k are listed.

	Kemi						Märket						Kalbådagrund					
	$\overline{u}$	SD	a	r	c	k	$\overline{u}$	SD	a	r	c	k	$\overline{u}$	SD	a	r	c	k
JAN	10.1	5.1	3.89	0.39	11.3	1.98	12.3	4.7	6.87	0.56	13.8	2.78	12.3	5.1	5.81	0.47	13.8	2.55
FEB	8.4	5.6	2.22	0.27	9.8	1.71	9.9	4.4	5.04	0.51	11.1	2.21	10.1	4.2	5.75	0.57	11.1	2.34
MAR	9.7	4.2	5.20	0.54	10.7	2.21	11.2	4.6	6.07	0.54	12.3	2.33	10.0	4.2	5.77	0.58	11.0	2.31
APR	8.4	3.7	5.25	0.62	9.2	2.13	9.6	4.6	4.36	0.46	10.3	1.86	9.3	4.0	5.48	0.59	10.3	2.25
MAY	8.9	3.4	7.09	0.79	9.9	2.67	9.1	3.3	7.58	0.83	10.0	2.58	9.8	3.6	7.64	0.78	11.0	2.89
JUN	8.9	3.5	6.42	0.72	9.8	2.51	9.2	3.6	6.47	0.70	10.1	2.34	10.0	4.2	5.65	0.56	10.9	2.17
JUL	8.0	3.7	4.71	0.59	8.9	2.16	7.5	3.2	5.41	0.72	8.2	2.12	7.8	3.7	4.55	0.58	8.3	1.79
AUG	9.4	4.1	5.34	0.57	10.4	2.30	9.9	3.9	6.38	0.64	11.0	2.48	9.4	3.9	5.81	0.62	10.3	2.28
SEP	10.2	4.5	5.14	0.50	11.2	2.19	11.1	5.1	4.71	0.43	11.9	1.92	10.5	4.9	4.67	0.44	11.7	2.12
OCT	13.0	5.2	6.13	0.47	14.4	2.42	12.1	4.9	6.07	0.50	13.5	2.39	12.2	4.3	8.18	0.67	13.4	2.79
NOV	12.7	5.5	5.28	0.41	14.0	2.16	13.8	5.2	7.09	0.51	15.1	2.50	13.1	4.7	7.70	0.59	14.7	3.00
DEC	10.3	5.5	3.46	0.34	11.7	2.05	12.5	4.5	7.79	0.62	13.9	2.89	12.4	4.9	6.29	0.51	13.7	2.46

As shown in Fig. 9, maximum velocity (gust) may also be described satisfactorily by a theoretical distribution, e.g. by the Gamma distribution

$$P(x) = \frac{r^a}{\Gamma(a)} x^{(a-1)} \exp\left[-rx\right] \qquad (8)$$

where r and a are parameters and Γ(a) is the Gamma function. With its narrower peak the Gamma distribution fits the maximum wind in our data somewhat better than does the Weibull distribution. The mean monthly parameters r and a are listed in Table 5.

The fitted theoretical distributions serve as an appropriate basis for estimating the distribution of gusts, for example, for estimating the maximum wind loads on structures.

3.5.2 Strong and stormy wind statistics

Statistics on the seasonal and annual strong (>10 m/s) and stormy (>20 m/s) winds, calculated as percentages from the mean wind speed observations, are given in Table 6. The results correspond to an observation height of 10 m, the velocities being corrected before calculation of the percentages.

TABLE 6. Number of strong winds and storms, expressed in percentages, at Kalbådagrund, Märket and Kemi.

		Spring	Summer	Fall	Winter	Year
Kalbådagrund	u>10 m/s	9.2	7.2	22.8	22.6	15.5
	u>20 m/s	0	0	0	0.03	0.008
Märket	u>10 m/s	12.2	7.2	27.3	21.5	17.1
	u>20 m/s	0.1	0	0.4	0	0.12
Kemi	u>10 m/s	6.5	6.5	24.7	16.5	13.6
	u>20 m/s	0	0	0.3	0.05	0.09

TABLE 7. Percentage of those 3-hour periods in which the gust has exceeded 20 m/s.

		Spring	Summer	Fall	Winter	Year
Kalbådagrund	u_{gust}>20 m/s	0.4	0.8	2.2	1.6	1.2
Märket	u_{gust}>20 m/s	1.5	0.3	5.5	2.8	2.5
Kemi	u_{gust}>20 m/s	0.4	0.14	4.1	1.9	1.6

Table 6 shows that in spring and summer 6—12 %, and in autumn and winter 16—27 % of the winds are strong. Storms are rare, being no more than 0 to 2 times a year; in some years there are none at all. The Gulf of Bothnia seems to be somewhat more stormy than the Gulf of Finland. The statistics, however, is based on data gathered during a limited period.

Statistics on stormy gusts (maximum wind) are given in Table 7, which shows that the velocity of a stormy wind is reached momentarily in spring and summer in 0.15—1.5 % of the observations, and in autumn and winter in 1.6—5.5 % of the observations. In all, this means 45 to 85 cases a year.

Table 6 and 7 as well as Fig. 8 reveal the importance of a definement of the averaging period; if the storms are defined on the 10 min. mean wind basis, they are in this data either very rare of they do not occur at all every year, whereas stormy gusts are fairly frequent. Depending on averaging period, intermediate results can also be obtained, which may give relevant information for various groups of users.

3.6 COMPARISON OF OPEN SEA WIND CONDITIONS WITH COASTAL OBSERVATIONS

As revealed in Fig. 2 (Nyhamn versus Märket and Ulkokalla versus Kemi), if carefully sited a coastal or archipelago station may represent ''marine'' conditions rather well. Figure 10 gives monthly mean wind speeds from long-period observations at several synoptic stations in coastal or archipelago areas and, for reference, at two inland stations. Referring to Fig. 10 and to the discussion above (cf. Fig. 2) we can draw the following conclusions:

- Mean surface wind speeds are distinctly (40 to 100 %) higher over the sea than over land.
- Wind speed has a more obvious annual course under marine than under inland conditions.
- The coastal region may represent marine or inland conditions, depending on the direction of the wind field.

With reference to the last finding, Fig. 11 gives the overall result of a case study in which the wind observed on the open sea (Kalbådagrund) was compared with that simultaneously observed at an automatic mast station in the Loviisa Archipelago. Figure 11 gives the wind speed ratio u_K/u_L, (wind speed over the open sea to that in the coastal area) for two directional classes: winds from the open sea (11A) and from land (11B). As shown in Fig. 11A, when winds blow from the open sea, the wind speed observed in the coastal region differs apparently less from that observed over the open sea, whereas when they blow from the land the average wind speed ratio is 1.4 to 1.6. The wind speed ratio tends towards unity with increasing wind speed. The physics of the above lies principally in the difference in the roughness conditions above the water and the ground. The wind speed ratio was also found to depend on stability conditions.

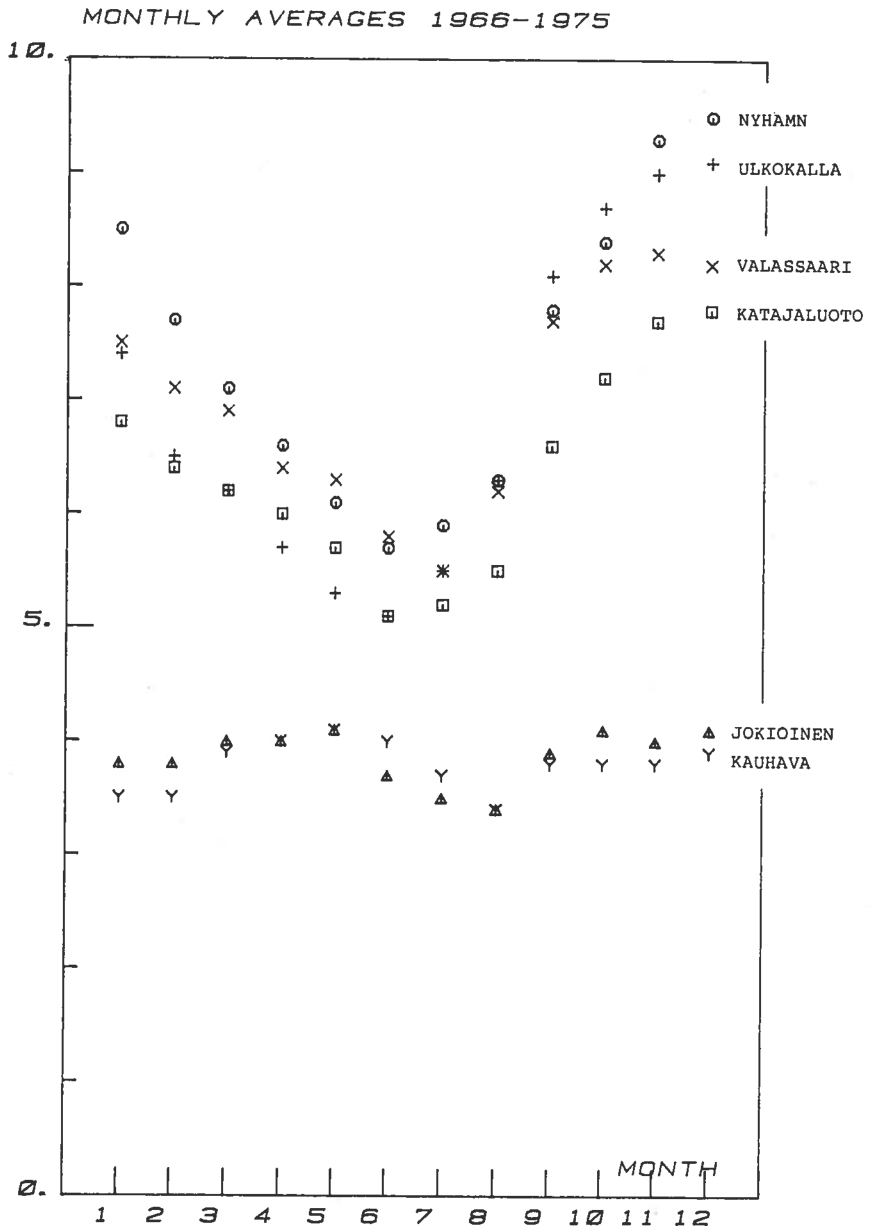

FIG. 10. Mean annual course of the wind speed at several synoptic weather stations (1966—1975). Nyhamn, Ulkokalla and Valassaaret represent "marine" conditions, revealing distinct seasonal variations. Jokioinen and Kauhava represent "land" conditions. Katajaluoto is situated near the coastal region and may represent "marine" or "coastal" conditions, depending mainly on the direction of the wind field.

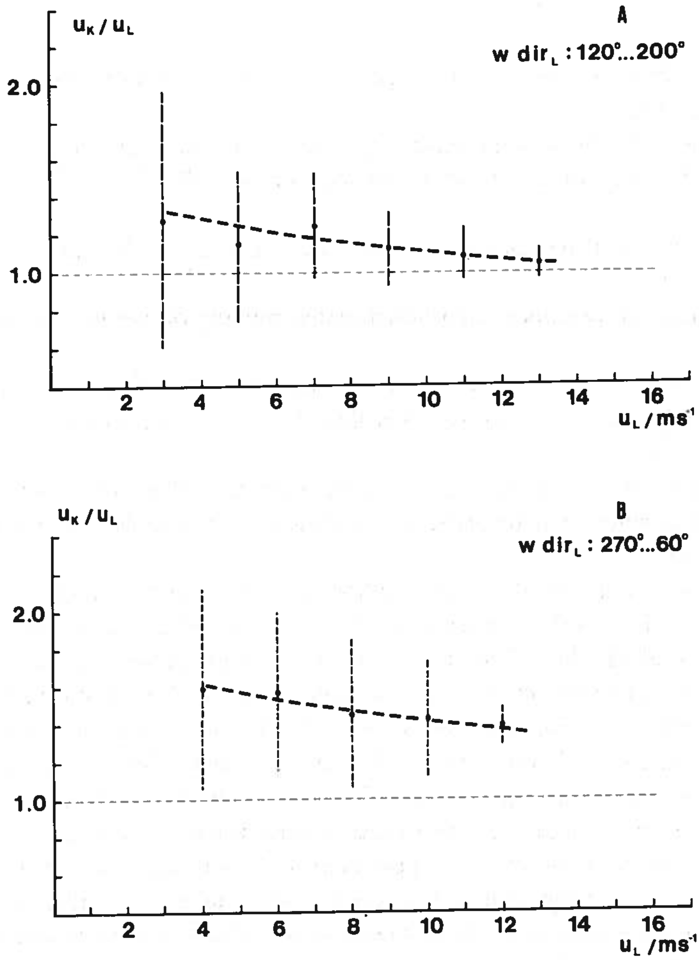

FIG. 11. A case study of the surface wind over the open sea compared to that in the coastal region. The relation u_K/u_L, i.e. the wind speed at Kalbådagrund to the wind observed simultaneously in a coastal archipelago at Loviisa region, is given for winds from open sea directions in 11A and for winds from land directions in 11B. (The effect due to the difference in the observation levels has been removed.) (Reprocessed from Launiainen et al., 1982.)

4. CONCLUDING REMARKS

The purpose of this study was to gain further information from marine wind conditions. The most essential findings are listed as follows:

— Wind speeds over the sea are distinctly (40 to 100 %) higher than over land.

— Long-period averages of the wind speed over the open sea do not seem to vary much within or between the different sea areas.

— The annual variation in the mean wind is more apparent under "marine" than "inland" conditions.

— The mean annual course of the wind speed and its variance over the sea can be expressed by a harmonic wave.
— Especially during the light-wind seasons (spring, early summer) modification by the sea is evident in the directional distribution of the wind as well (alignment parallel to the sea recipient).
— The coastal region may represent marine or inland conditions, depending on the direction of the wind field.
— The maximum wind (gustiness) can be estimated roughly on the basis of the mean wind speed.
— Storms ($u > 20$ m/s), if defined by the mean wind basis (of 10 min.) are rare; only 0 to 2 cases annually. In gusts, however, this limit is exceeded in 45 to 85 cases of 3-hour measuring periods.
— Frequency statistics of the mean and maximum wind, as well as the mean wind power density, is well approximated by theoretical distribution functions (Weibull distribution, Gamma distribution).

The study was based primarily on observations from the recent automatic marine weather stations (ODAS station) and, hence, a few words are appropriate about the gathering and statistical coverage of the data. The data for the study were gathered in two different ways: with climatological cassettes recorded at the stations or, with synoptic telecommunicated messages. For research, the data recorded at the station are easiest to handle and of the highest quality because they cover misfunctioning in the telecommunications or the central processing unit. However, because of the practical difficulty of servicing the stations, there have been occasions when a cassette unit has not functioned or when the tape has run out, and as a result data are lacking. For this reason and because the study was based on a rather limited period, further statistics from marine wind characteristics are required. In addition to the routine weather survey, this encourages us to maintain the automatic marine weather stations, even though this has been turned out to be a costly and laborious task.

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APPENDIX 1.Monthly mean wind velocity components (in m/s) at Kemi, Märket and Kalbådagrund. Positive values are towards east and north. Results are given if at least 90 % of the observations are available.

		Kemi		Märket		Kalbådagrund	
		E	N	E	N	E	N
1977	NOV					1.5	3.9
	DEC					0.3	0.5
1978	JAN					1.4	2.8
	FEB					—2.6	—0.3
	MAR			—1.7	0.5	—1.4	1.0
	APR					—1.0	—1.0
	MAY	—0.0	—0.6	—1.2	—1.6	—2.3	—1.4
	JUN	—2.3	—1.0	—0.5	0.7		
	JUL	—0.0	—0.2	—0.6	0.1		
	AUG	—1.9	—0.9				
	SEP	—2.5	0.1	0.3	—2.3	—1.0	0.1
	OCT	4.4	—1.3	4.7	0.2	5.2	0.3
	NOV	4.8	0.6	5.2	1.3		
	DEC			—1.8	—0.9	—1.4	—2.3
1979	JAN			—1.0	—1.0	—2.5	0.5
	FEB					2.3	1.1
	MAR			—0.5	3.2	—0.9	3.1
	APR	—1.9	0.0			—0.4	—0.2
	MAY	2.7	3.1	—0.2	5.0	2.5	3.3
	JUN	3.0	1.1			4.6	1.5
	JUL	—2.4	0.2			1.0	1.7
	AUG	0.5	2.2	—0.1	1.8	—0.2	1.4
	SEP	2.8	0.2	4.7	1.5	5.2	1.5
	OCT			1.6	—0.3	2.8	—0.9
	NOV			1.4	3.7	1.1	4.4
	DEC					1.3	2.8
1980	JAN					0.7	—0.3
	FEB			2.2	1.0	1.9	1.8
	MAR	—0.4	3.1	—2.0	1.7	—3.2	1.1
	APR	—0.1	0.6	0.2	—1.8	—1.0	0.5
	MAY	—0.3	—0.2	—0.4	—1.8	—0.7	—0.3
	JUN	0.9	1.7	—1.7	2.2	—1.1	0.3
	JUL	—1.8	—0.4			—1.6	—0.5
	AUG	—3.1	—0.9	—0.1	—2.2	—0.5	—0.3
	SEP	1.4	2.9	1.7	2.5	0.6	1.6
	OCT			—0.2	—0.2	—1.3	3.0
	NOV			2.1	—2.7	4.0	0.2
	DEC			3.3	0.1	3.6	3.3
1981	JAN			4.6	—0.1	3.6	4.3
	FEB					—1.6	0.2
	MAR			0.1	0.8	—0.1	1.1
	APR			—2.2	2.5	—1.6	1.0
	MAY						
	JUN						
	JUL						
	AUG						
	SEP						
	OCT						
	NOV			1.9	—0.7		
	DEC			—1.4	—3.8		
1982	JAN			2.2	—1.1		
	FEB			2.4	2.5		
	MAR			0.9	3.5	1.1	2.5
	APR	1.2	—0.0			2.5	1.7
	MAY	1.5	0.4			2.3	1.9
	JUN	0.3	—2.8			1.3	—1.9
	JUL	3.0	0.8			0.8	—0.8
	AUG					2.8	3.1
	SEP					3.6	2.3
	OCT					0.2	0.4

APPENDIX 2. Monthly frequency distributions of mean wind speed (of 10 min) and maximum gust for Kemi, Märket, Kalbådagrund and Ulkokalla. Frequency distributions are given in percentages at 2 m/s velocity intervals. In addition, monthly mean, standard deviation and maximum velocity and percentage of observations available are given.

KEMI 1978 MEAN WIND SPEED

PERIOD	0	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	MEAN	SD	MAX	% OBS
1. 1.-31. 1.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1. 2.-28. 2.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1. 3.-31. 3.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1. 4.-30. 4.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1. 5.-31. 5.	6.8	18.6	19.1	25.9	17.3	11.4	.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.3	2.8	13.1	88.7
1. 6.-30. 6.	3.3	20.0	22.1	21.7	20.8	7.5	4.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.5	2.9	13.9	100.0
1. 7.-31. 7.	10.5	30.2	21.4	14.1	12.5	6.5	2.8	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.5	3.3	14.5	100.0
1. 8.-31. 8.	2.9	16.1	23.6	24.0	19.0	12.0	1.7	.4	.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.7	2.9	16.1	97.6
1. 9.-30. 9.	8.3	14.8	15.3	17.5	16.6	14.8	6.6	3.9	.9	.9	.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.5	4.0	20.3	95.4
1.10.-31.10.	4.1	6.2	7.0	10.7	17.3	23.0	14.4	10.7	4.5	2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.0	4.1	19.4	98.0
1.11.-30.11.	0.0	7.9	22.4	14.5	13.6	14.0	14.0	6.6	4.4	.9	.9	.4	.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.2	4.3	25.7	95.0
1.12.-31.12.	5.1	23.1	24.8	21.4	12.0	6.8	5.1	0.0	1.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.2	3.2	17.1	47.2

KEMI 1979 MEAN WIND SPEED

PERIOD	0	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	MEAN	SD	MAX	% OBS
1. 1.-31. 1.	11.2	22.3	28.7	16.8	12.3	12.8	2.8	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.0	3.5	14.6	72.2
1. 2.-28. 2.	7.4	19.1	16.2	21.3	14.7	14.0	4.4	1.5	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.7	3.6	17.2	60.7
1. 3.-31. 3.	5.3	12.2	13.8	21.2	23.3	9.0	9.0	2.6	1.6	1.1	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.9	4.0	21.3	76.2
1. 4.-30. 4.	7.7	25.9	26.4	21.4	11.4	4.5	1.8	.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.4	3.0	14.3	91.7
1. 5.-31. 5.	4.1	14.7	22.1	25.8	18.4	10.1	4.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.8	2.9	13.7	87.5
1. 6.-30. 6.	4.2	16.0	23.1	29.0	19.7	5.9	2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.3	2.7	13.8	99.2
1. 7.-31. 7.	8.5	29.0	19.0	18.1	15.7	7.7	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.6	3.1	13.0	100.0
1. 8.-31. 8.	9.3	15.7	22.6	21.0	15.3	9.3	3.6	3.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.4	3.5	15.8	100.0
1. 9.-30. 9.	2.5	11.3	17.9	22.5	15.8	15.8	10.0	2.1	2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.9	3.6	16.9	100.0
1.10.-31.10.	3.0	11.2	19.4	20.9	17.2	10.4	6.7	3.0	5.2	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.3	4.3	19.2	54.0
1.11.-30.11.	1.2	11.1	19.8	18.5	16.0	16.0	6.2	3.7	6.2	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.4	4.0	18.4	33.8
1.12.-31.12.	4.9	14.0	12.2	7.9	12.8	14.6	17.1	11.6	4.3	.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.1	4.7	18.0	66.1

KEMI 1980 MEAN WIND SPEED

PERIOD	0	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	MEAN	SD	MAX	% OBS
1. 1.-31. 1.	16.7	13.3	13.8	20.0	12.9	12.4	9.0	1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.6	4.0	15.9	84.7
1. 2.-29. 2.	13.8	30.2	11.2	15.5	8.6	9.5	3.4	2.6	4.3	.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.3	4.4	18.3	50.0
1. 3.-31. 3.	8.1	18.5	18.5	30.2	19.4	4.0	.8	.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.0	2.7	15.6	100.0
1. 4.-30. 4.	7.5	22.5	26.7	30.4	10.0	2.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.3	2.4	10.8	100.0
1. 5.-31. 5.	10.5	22.2	34.3	23.4	6.5	3.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.1	2.4	11.6	100.0
1. 6.-30. 6.	5.4	20.4	26.7	16.7	19.2	6.7	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.2	3.1	13.8	100.0
1. 7.-31. 7.	14.9	33.9	23.0	10.5	10.5	4.4	2.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.8	3.1	13.8	100.0
1. 8.-31. 8.	9.7	16.1	21.4	17.7	14.5	8.1	6.9	4.4	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.8	3.9	17.2	100.0
1. 9.-30. 9.	5.9	16.3	28.5	22.6	9.6	10.0	4.2	1.7	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.4	3.3	17.4	99.6
1.10.-31.10.	4.9	7.3	12.2	17.1	22.0	31.7	4.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.2	3.1	13.1	16.5
1.11.-30.11.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.12.-31.12.	34.4	19.7	9.8	14.8	6.6	6.6	1.6	4.9	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0	4.3	17.2	24.6

KEMI 1981 MEAN WIND SPEED

PERIOD	0	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	MEAN	SD	MAX	% OBS
1. 1.-31. 1.	7.1	8.8	13.7	14.3	14.8	11.5	14.3	8.2	4.4	1.6	.5	0.0	.5	0.0	0.0	0.0	0.0	0.0	0.0		8.9	4.8	24.4	73.4
1. 2.-28. 2.	63.5	14.8	5.2	5.2	7.8	2.6	0.0	0.0	.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		2.5	3.3	17.9	51.3
1. 3.-31. 3.	0.0	0.0	0.0	0.0	12.5	12.5	62.5	12.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		12.6	1.6	14.3	3.2
1. 4.-30. 4.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
1. 5.-31. 5.	2.7	17.0	26.8	32.1	16.1	4.5	.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		6.2	2.4	12.6	45.2
1. 6.-30. 6.	0.0	14.3	28.6	28.6	14.3	7.1	7.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		6.8	3.0	13.9	5.8
1. 7.-31. 7.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
1. 8.-31. 8.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
1. 9.-30. 9.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
1.10.-31.10.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
1.11.-30.11.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
1.12.-31.12.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0

KEMI 1982 MEAN WIND SPEED

PERIOD	0	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	MEAN	SD	MAX	% OBS
1. 1.-31. 1.	1.3	10.7	29.3	40.0	12.0	5.3	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		6.4	2.2	12.0	30.2
1. 2.-28. 2.	8.5	18.6	10.2	16.1	22.9	13.6	6.8	.8	2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		7.2	3.8	17.3	52.7
1. 3.-31. 3.	5.7	11.0	19.5	25.7	21.4	9.0	6.2	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		7.1	3.1	15.3	84.7
1. 4.-30. 4.	2.1	8.4	29.3	25.9	16.3	11.3	4.2	1.3	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		7.1	3.0	17.3	99.6
1. 5.-31. 5.	3.6	10.1	18.6	32.4	21.1	10.1	3.6	.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		7.0	2.7	14.1	99.6
1. 6.-30. 6.	7.5	22.1	28.3	20.8	11.3	6.3	2.1	.8	.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		5.8	3.1	17.9	100.0
1. 7.-31. 7.	6.0	16.1	26.6	21.0	21.0	6.9	2.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		6.3	2.8	13.4	100.0
1. 8.-31. 8.	4.2	16.0	29.2	28.5	9.7	10.4	2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		6.3	2.6	13.0	58.1
1. 9.-30. 9.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
1.10.-31.10.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
1.11.-30.11.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
1.12.-31.12.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0

MÄRKET 1978 MEAN WIND SPEED

PERIOD	0	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	MEAN	SD	MAX	% OBS
1. 1.-31. 1.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
1. 2.-28. 2.	1.0	12.2	13.3	20.4	20.4	15.3	6.1	4.1	5.1	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		8.6	3.9	19.2	43.8
1. 3.-31. 3.	2.0	10.9	20.6	16.9	17.7	15.7	10.5	2.4	1.6	1.2	.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		8.1	3.8	20.4	100.0
1. 4.-30. 4.	16.7	19.4	16.7	8.3	8.3	16.7	8.3	5.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		6.6	4.3	14.9	15.0
1. 5.-31. 5.	7.8	17.7	30.2	25.9	10.3	3.4	2.6	2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		5.8	2.9	15.6	93.5
1. 6.-30. 6.	6.3	14.2	20.8	25.8	15.8	8.8	5.4	2.5	.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		6.8	3.4	16.6	100.0
1. 7.-31. 7.	4.5	19.5	26.2	24.4	17.6	5.0	2.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		6.1	2.6	13.6	89.1
1. 8.-31. 8.	4.6	9.9	12.5	23.0	23.7	11.2	10.5	4.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		7.9	3.4	14.5	61.3
1. 9.-30. 9.	6.0	9.8	16.6	20.0	15.3	9.4	6.0	6.8	7.2	2.1	.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		8.6	4.7	20.3	97.9
1.10.-31.10.	2.9	10.2	11.5	19.3	18.4	16.8	9.0	6.6	4.1	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		8.8	4.0	19.1	98.4
1.11.-30.11.	.9	3.4	8.5	15.4	20.5	15.4	19.7	9.8	3.4	2.1	.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		10.3	3.8	21.6	97.5
1.12.-31.12.	3.8	9.8	22.6	22.6	17.4	17.0	4.3	2.1	.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		7.4	3.2	16.1	94.8

MARKET 1979 MEAN WIND SPEED

PERIOD	0	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	MEAN	SD	MAX	% OBS
1. 1.-31. 1.	7.0	16.1	17.0	15.7	13.9	13.0	9.6	4.8	2.6	.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		7.6	4.1	18.7	92.7
1. 2.-28. 2.	7.5	13.3	17.9	22.0	19.1	16.8	2.3	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		6.9	3.1	15.2	77.2
1. 3.-31. 3.	.4	3.7	8.2	23.8	19.3	16.4	11.1	11.5	5.3	.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		9.8	3.6	18.4	98.4
1. 4.-30. 4.	3.2	10.8	20.4	23.7	26.3	10.8	1.1	1.1	1.6	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		7.3	3.2	19.2	77.5
1. 5.-31. 5.	2.2	7.9	11.0	28.2	32.2	11.0	6.2	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		7.8	2.7	15.7	91.5
1. 6.-30. 6.	7.4	16.4	21.2	31.2	16.9	5.3	.5	0.0	.5	.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		6.1	2.9	18.0	78.8
1. 7.-31. 7.	12.4	22.5	30.3	18.5	13.5	2.2	.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		5.1	2.7	13.6	71.8
1. 8.-31. 8.	3.6	13.3	21.8	30.2	15.3	10.1	4.0	1.2	0.0	.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		6.9	3.1	18.6	100.0
1. 9.-30. 9.	2.9	6.7	16.3	17.1	26.7	12.1	8.3	5.8	2.1	2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		8.6	3.8	19.4	100.0
1.10.-31.10.	5.6	9.7	16.1	19.0	21.0	19.4	7.7	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		7.7	3.4	15.8	100.0
1.11.-30.11.	1.8	7.1	10.7	19.6	21.8	20.0	9.8	4.9	.9	1.8	1.3	.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0		9.2	3.9	22.5	93.8
1.12.-31.12.	4.0	8.6	20.6	13.1	18.9	20.0	9.7	2.9	.6	1.1	.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		8.3	3.9	21.4	70.6

MARKET 1980 MEAN WIND SPEED

PERIOD	0	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	MEAN	SD	MAX	% OBS
1. 1.-31. 1.	1.4	10.1	15.7	15.2	15.2	21.2	11.1	4.1	4.1	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		8.9	3.9	18.8	87.5
1. 2.-29. 2.	10.8	22.0	20.7	19.4	20.7	4.7	1.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		5.7	3.1	13.6	100.0
1. 3.-31. 3.	2.4	7.7	25.1	30.8	15.0	9.7	3.2	4.0	1.2	0.0	.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		7.4	3.4	20.9	99.6
1. 4.-30. 4.	14.6	20.0	20.0	22.1	8.8	9.2	2.5	2.1	.4	.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		5.8	3.6	18.0	100.0
1. 5.-31. 5.	6.1	13.0	20.2	30.0	22.7	8.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		6.5	2.5	11.8	99.6
1. 6.-30. 6.	5.9	14.8	27.8	23.2	12.7	11.4	2.1	1.7	.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		6.5	3.1	16.4	98.8
1. 7.-31. 7.	13.3	38.3	33.3	9.4	3.9	1.1	.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		4.1	2.1	12.3	72.6
1. 8.-31. 8.	5.6	17.3	20.6	23.4	18.1	8.5	3.6	1.6	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		6.7	3.3	17.8	100.0
1. 9.-30. 9.	3.3	17.5	27.5	17.9	20.0	12.9	.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		6.5	2.8	12.7	100.0
1.10.-31.10.	4.4	4.8	7.3	10.9	21.8	21.0	14.1	10.1	2.8	1.2	.8	.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0		9.9	4.2	23.2	100.0
1.11.-30.11.	2.5	5.0	15.8	17.5	19.6	12.9	9.2	9.6	5.4	1.7	.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		9.4	4.2	21.0	100.0
1.12.-31.12.	.4	5.6	10.9	14.9	24.2	20.6	9.7	10.1	2.4	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		9.6	3.6	19.7	100.0

MARKET 1981 MEAN WIND SPEED

PERIOD	0	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	MEAN	SD	MAX	% OBS
1. 1.-31. 1.	1.3	5.5	7.6	13.9	24.5	23.6	11.4	9.7	2.1	.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		9.7	3.4	18.5	95.6
1. 2.-28. 2.	3.8	12.6	15.8	24.0	20.2	9.3	7.7	4.4	1.1	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		7.7	3.8	18.3	81.7
1. 3.-31. 3.	4.0	14.1	20.6	23.4	17.3	7.7	5.6	3.6	2.8	.4	.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		7.4	3.9	20.1	100.0
1. 4.-30. 4.	2.9	18.0	17.6	23.4	14.2	13.0	5.0	1.7	2.1	1.3	.4	.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0		7.5	3.9	23.8	99.6
1. 5.-31. 5.	5.0	15.4	27.0	31.1	15.4	3.7	1.2	.8	.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		6.1	2.7	16.3	97.2
1. 6.-30. 6.	0.0	0.0	0.0	57.1	28.6	0.0	14.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		8.3	2.0	12.3	5.8
1. 7.-31. 7.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
1. 8.-31. 8.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
1. 9.-30. 9.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
1.10.-31.10.	6.1	17.2	17.2	22.2	15.2	9.1	3.0	5.1	2.0	2.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		7.4	4.2	20.8	39.9
1.11.-30.11.	3.3	4.6	13.0	10.0	13.4	13.8	18.0	9.6	7.9	4.2	.8	.4	.8	0.0	0.0	0.0	0.0	0.0	0.0		10.6	4.9	25.3	99.6
1.12.-31.12.	1.7	4.6	11.7	10.5	19.2	17.2	18.4	8.8	5.4	2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		10.1	4.1	18.8	96.4

MARKET 1982 MEAN WIND SPEED

PERIOD	0	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	MEAN	SD	MAX	% OBS
1. 1.-31. 1.	1.6	6.1	13.4	20.3	22.4	17.9	8.1	6.1	3.3	.4	.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.9	3.7	20.6	99.2
1. 2.-28. 2.	4.0	10.3	22.0	28.3	22.4	9.9	2.7	.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.9	2.8	14.1	99.6
1. 3.-31. 3.	2.4	7.7	18.1	26.2	20.2	13.3	6.9	4.0	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.9	3.3	16.3	100.0
1. 4.-30. 4.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1. 5.-31. 5.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1. 6.-30. 6.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1. 7.-31. 7.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1. 8.-31. 8.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1. 9.-30. 9.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.10.-31.10.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.11.-30.11.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.12.-31.12.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

KALBADAGRUND 1977 MEAN WIND SPEED

PERIOD	0	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	MEAN	SD	MAX	% OBS
1. 1.-31. 1.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1. 2.-28. 2.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1. 3.-31. 3.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1. 4.-30. 4.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1. 5.-31. 5.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1. 6.-30. 6.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1. 7.-31. 7.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1. 8.-31. 8.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1. 9.-30. 9.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.10.-31.10.	2.6	8.2	16.3	19.4	24.5	17.3	6.6	4.1	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.1	3.3	17.1	79.0
1.11.-30.11.	4.2	8.8	14.6	15.4	18.3	19.2	12.1	6.3	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.6	3.8	17.2	100.0
1.12.-31.12.	4.0	6.5	10.5	17.3	14.1	17.3	17.3	6.0	4.0	2.0	.4	.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.5	4.2	22.5	100.0

KALBADAGRUND 1978 MEAN WIND SPEED

PERIOD	0	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	MEAN	SD	MAX	% OBS
1. 1.-31. 1.	2.4	9.7	13.7	21.4	14.5	10.9	16.5	7.7	2.4	.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.9	4.0	18.4	100.0
1. 2.-28. 2.	0.0	4.0	30.8	26.3	19.2	13.4	3.1	3.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.6	2.7	15.9	100.0
1. 3.-31. 3.	4.0	11.3	17.7	25.8	23.8	6.9	8.1	2.0	.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.3	3.2	16.8	100.0
1. 4.-30. 4.	8.8	21.3	21.3	17.1	15.0	6.3	3.3	5.4	1.3	.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.4	3.9	18.1	100.0
1. 5.-31. 5.	7.7	10.5	15.7	23.0	28.2	8.1	4.0	2.4	.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.1	3.3	16.2	100.0
1. 6.-30. 6.	3.6	13.0	23.2	23.9	19.6	11.6	4.3	.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.9	3.0	14.1	57.5
1. 7.-31. 7.	9.8	41.4	23.3	9.8	12.8	2.3	.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.6	2.6	12.0	53.6
1. 8.-31. 8.	5.3	15.4	22.1	19.7	20.2	9.1	4.8	2.4	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.9	3.4	16.3	83.9
1. 9.-30. 9.	6.1	10.9	18.7	20.0	16.1	13.0	8.7	4.3	1.7	.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.7	3.9	18.4	95.8
1.10.-31.10.	1.3	5.7	11.4	17.5	21.8	20.1	16.2	5.2	.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.2	3.3	16.2	92.3
1.11.-30.11.	3.3	6.6	9.0	20.5	11.5	13.1	14.8	11.5	8.2	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.9	4.4	19.1	50.8
1.12.-31.12.	5.3	7.8	21.0	21.4	15.6	16.0	7.4	4.1	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.7	3.6	17.5	98.0

KALBADAGRUND 1979 MEAN WIND SPEED

PERIOD	0	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	MEAN	SD	MAX	% OBS
1. 1.-31. 1.	3.6	12.5	18.5	14.1	13.3	12.5	9.7	7.3	6.5	1.2	.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.7	4.6	20.6	100.0
1. 2.-28. 2.	5.8	15.6	17.0	22.8	20.1	12.9	4.5	.9	.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.9	3.2	17.4	100.0
1. 3.-31. 3.	.4	4.0	17.3	33.5	16.9	13.7	7.3	5.2	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.3	3.1	16.8	100.0
1. 4.-30. 4.	7.9	14.2	25.4	20.4	16.3	8.8	4.2	2.1	.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.5	3.4	17.9	100.0
1. 5.-31. 5.	2.0	9.3	11.7	23.4	26.2	19.0	6.9	1.2	.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.1	3.0	16.3	100.0
1. 6.-30. 6.	3.4	8.2	19.7	27.5	21.5	13.3	4.3	1.3	.4	.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.5	3.1	19.3	97.1
1. 7.-31. 7.	8.6	24.4	33.0	19.5	5.9	5.4	2.3	.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.4	2.9	15.7	89.1
1. 8.-31. 8.	6.7	14.6	21.3	21.8	18.0	11.3	4.2	1.3	.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.8	3.2	17.1	96.4
1. 9.-30. 9.	5.1	10.5	11.0	15.2	16.5	18.6	9.7	5.5	4.6	1.3	1.7	.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.0	4.6	22.4	98.8
1.10.-31.10.	3.2	8.9	15.4	17.0	21.9	19.8	7.7	4.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.3	3.5	16.8	99.6
1.11.-30.11.	1.7	9.2	14.6	14.6	21.7	12.9	11.7	5.8	6.7	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.1	4.1	18.8	100.0
1.12.-31.12.	3.2	12.9	12.9	14.1	21.0	12.1	13.3	6.9	3.2	.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.6	4.0	19.9	100.0

KALBADAGRUND 1980 MEAN WIND SPEED

PERIOD	0	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	MEAN	SD	MAX	% OBS
1. 1.-31. 1.	2.0	17.8	23.5	15.4	11.3	15.4	8.1	3.6	2.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.6	3.8	17.7	99.6
1. 2.-29. 2.	4.8	24.3	24.8	20.0	11.4	10.5	3.3	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.2	3.2	17.1	90.5
1. 3.-31. 3.	9.7	19.4	21.4	24.2	17.3	6.9	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.9	2.8	13.1	100.0
1. 4.-30. 4.	14.2	10.8	22.5	24.2	18.8	7.5	1.7	.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.0	3.1	14.8	100.0
1. 5.-31. 5.	6.5	15.0	21.9	27.1	17.4	8.1	3.2	.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.5	3.0	15.3	99.6
1. 6.-30. 6.	7.9	15.5	22.2	20.5	15.9	10.5	4.6	2.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.7	3.5	15.9	99.6
1. 7.-31. 7.	10.1	25.4	27.4	16.1	10.9	3.6	3.2	1.6	.4	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.6	3.5	18.8	100.0
1. 8.-31. 8.	11.3	17.3	22.2	21.0	19.0	5.6	3.2	.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.0	3.1	14.6	100.0
1. 9.-30. 9.	10.0	20.8	21.7	20.4	14.6	7.5	4.2	.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.9	3.2	14.7	100.0
1.10.-31.10.	.4	4.4	8.5	19.0	21.4	25.0	11.7	5.6	2.0	.8	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.6	3.5	20.4	100.0
1.11.-30.11.	2.5	9.6	10.8	20.8	15.4	17.1	12.1	5.8	4.6	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.1	4.1	19.8	100.0
1.12.-31.12.	1.2	6.9	13.3	23.4	16.1	12.5	12.1	7.7	6.0	.4	.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.2	4.0	20.3	100.0

KALBADAGRUND 1981 MEAN WIND SPEED

PERIOD	0	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	MEAN	SD	MAX	% OBS
1. 1.-31. 1.	2.0	5.7	12.2	14.6	15.4	14.2	13.4	12.6	7.3	2.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.1	4.3	18.8	99.2
1. 2.-28. 2.	4.0	11.6	19.6	22.3	15.6	10.3	8.9	4.5	2.2	.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.8	3.9	19.1	100.0
1. 3.-31. 3.	4.8	16.1	22.6	21.0	16.5	8.1	4.0	4.4	2.0	.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.1	3.7	18.3	100.0
1. 4.-30. 4.	4.2	10.4	15.0	27.1	22.1	12.1	7.9	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.5	3.1	15.3	100.0
1. 5.-31. 5.	5.8	16.1	24.8	18.6	19.8	11.6	2.5	.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.6	3.0	14.6	97.6
1. 6.-30. 6.	0.0	21.4	21.4	7.1	21.4	21.4	7.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.3	3.0	12.2	5.8
1. 7.-31. 7.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1. 8.-31. 8.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1. 9.-30. 9.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.10.-31.10.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.11.-30.11.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.12.-31.12.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

KALBADAGRUND 1982 MEAN WIND SPEED

PERIOD	0	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	MEAN	SD	MAX	% OBS
1. 1.-31. 1.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1. 2.-28. 2.	0.0	2.3	30.2	20.9	18.6	14.0	14.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.0	2.9	13.6	19.2
1. 3.-31. 3.	4.3	9.1	20.7	26.7	21.1	11.6	5.2	.9	.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.2	3.0	16.1	93.5
1. 4.-30. 4.	6.3	15.0	15.0	25.8	19.6	11.3	6.3	.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.0	3.1	15.6	100.0
1. 5.-31. 5.	2.4	11.7	16.9	17.3	20.6	21.8	8.1	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.8	3.2	14.8	100.0
1. 6.-30. 6.	4.2	16.7	24.6	17.9	12.1	10.8	6.3	3.8	3.3	0.0	.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.3	4.0	20.0	100.0
1. 7.-31. 7.	6.5	16.9	28.6	24.2	18.5	4.4	.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.9	2.6	13.1	100.0
1. 8.-31. 8.	4.4	19.8	21.4	19.8	21.0	9.3	3.6	.4	.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.6	3.1	16.8	100.0
1. 9.-30. 9.	8.8	12.1	22.9	17.5	14.6	14.2	7.1	2.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.0	3.7	15.9	100.0
1.10.-31.10.	4.0	10.1	19.8	18.5	19.4	17.7	8.1	1.2	.8	.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.7	3.4	18.0	100.0
1.11.-30.11.	1.6	4.0	6.5	8.9	20.2	17.7	24.2	6.5	5.6	4.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.8	3.9	19.3	51.7
1.12.-31.12.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

ULKOKALLA 1978 MEAN WIND SPEED

PERIOD	0	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	MEAN	SD	MAX	% OBS
1. 1.-31. 1.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1. 2.-28. 2.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1. 3.-31. 3.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1. 4.-30. 4.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1. 5.-31. 5.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1. 6.-30. 6.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1. 7.-31. 7.	7.9	33.3	32.5	13.5	9.5	3.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.7	2.3	10.9	50.8
1. 8.-31. 8.	5.3	27.2	33.5	21.4	9.7	2.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.2	2.3	11.6	83.1
1. 9.-30. 9.	4.0	21.8	26.2	26.7	11.1	4.0	3.6	2.2	.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.1	3.1	16.9	93.8
1.10.-31.10.	1.2	7.8	7.4	13.2	18.9	23.5	15.2	7.0	4.9	.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.8	3.8	19.0	98.0
1.11.-30.11.	1.5	4.5	10.5	14.5	19.5	18.5	18.0	7.5	2.5	2.0	.5	.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.9	3.9	22.0	83.3
1.12.-31.12.	2.3	14.0	27.9	25.6	20.9	7.0	2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.6	2.5	12.1	17.3

ULKOKALLA 1980 MEAN WIND SPEED

PERIOD	0	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	MEAN	SD	MAX	% OBS
1. 1.-31. 1.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1. 2.-29. 2.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1. 3.-31. 3.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1. 4.-30. 4.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1. 5.-31. 5.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1. 6.-30. 6.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1. 7.-31. 7.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1. 8.-31. 8.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1. 9.-30. 9.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.10.-31.10.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.11.-30.11.	.9	17.9	9.4	10.4	24.5	18.9	12.3	3.8	1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.5	3.7	17.4	44.2
1.12.-31.12.	2.1	9.1	18.7	21.9	15.0	20.3	6.4	3.2	2.1	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.3	3.6	18.8	75.4

ULKOKALLA 1981 MEAN WIND SPEED

PERIOD	0	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	MEAN	SD	MAX	% OBS
1. 1.-31. 1.	2.7	15.1	19.2	28.8	5.5	8.2	4.1	9.6	4.1	2.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		8.0	4.5	18.6	29.4
1. 2.-28. 2.	44.9	16.8	11.7	16.3	4.6	2.0	2.0	1.0	.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		3.7	3.5	16.5	87.5
1. 3.-31. 3.	11.1	17.1	30.3	17.1	12.4	5.6	3.4	2.1	.4	.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		5.9	3.5	19.5	94.4
1. 4.-30. 4.	8.7	27.9	26.4	13.9	11.5	6.7	2.9	1.4	.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		5.6	3.3	17.6	86.7
1. 5.-31. 5.	3.8	30.0	40.0	20.0	5.0	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		4.9	1.9	10.1	32.3
1. 6.-30. 6.	0.0	0.0	42.9	21.4	35.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		7.0	2.0	9.9	5.8
1. 7.-31. 7.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
1. 8.-31. 8.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
1. 9.-30. 9.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
1.10.-31.10.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
1.11.-30.11.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
1.12.-31.12.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0

KEMI 1978 GUST SPEED

PERIOD	0	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	MEAN	SD	MAX	% OBS
1. 1.-31. 1.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
1. 2.-28. 2.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
1. 3.-31. 3.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
1. 4.-30. 4.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
1. 5.-31. 5.	.5	4.5	16.4	16.4	23.6	18.2	12.3	6.4	.5	.5	.5	.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0		9.0	3.5	22.4	88.7
1. 6.-30. 6.	0.0	4.2	15.8	21.7	17.9	23.3	6.3	7.1	2.5	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		9.1	3.5	19.0	100.0
1. 7.-31. 7.	.8	8.1	30.2	19.4	12.5	12.5	8.1	3.6	4.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		7.9	3.8	17.5	100.0
1. 8.-31. 8.	1.2	4.9	12.7	19.2	19.2	19.2	13.1	6.5	2.4	.4	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		9.3	3.7	21.1	98.8
1. 9.-30. 9.	1.3	7.7	10.3	13.3	17.2	12.0	15.5	9.4	5.2	2.6	3.4	.4	1.3	.4	0.0	0.0	0.0	0.0	0.0		10.5	5.0	26.9	97.1
1.10.-31.10.	0.0	2.5	2.9	7.0	9.0	13.5	14.3	13.9	16.4	9.4	3.7	4.5	.8	.4	1.2	.4	0.0	0.0	0.0		14.1	5.2	30.1	98.4
1.11.-30.11.	0.0	0.0	10.0	14.0	12.7	13.5	10.5	11.8	10.9	7.4	3.5	2.6	0.0	1.3	.9	0.0	.4	.4	0.0		12.8	5.7	35.9	95.4
1.12.-31.12.	.8	8.4	12.6	28.6	19.3	14.3	7.6	2.5	3.4	.8	1.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		8.5	3.8	21.3	48.0

KEMI 1979 GUST SPEED

PERIOD	0	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	MEAN	SD	MAX	% OBS
1. 1.-31. 1.	3.9	7.8	19.6	16.8	14.0	12.3	15.6	5.6	2.8	1.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		8.6	4.2	18.4	72.2
1. 2.-28. 2.	.7	5.1	15.4	16.9	13.2	18.4	9.6	8.1	5.9	2.9	2.2	.7	.7	0.0	0.0	0.0	0.0	0.0	0.0		10.1	4.8	25.3	60.7
1. 3.-31. 3.	0.0	5.3	13.2	11.6	12.7	20.1	12.7	6.3	10.6	2.6	1.6	1.6	1.1	.5	0.0	0.0	0.0	0.0	0.0		10.9	4.9	26.4	76.2
1. 4.-30. 4.	2.3	8.6	24.5	24.5	20.5	7.3	5.5	4.1	.9	.9	.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		7.6	3.6	20.1	91.7
1. 5.-31. 5.	0.0	.5	11.5	18.4	25.8	17.1	13.4	9.2	1.8	1.8	.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		9.8	3.3	20.0	87.5
1. 6.-30. 6.	.4	2.5	12.6	23.1	24.8	22.3	8.4	3.8	2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		8.9	2.9	17.4	99.2
1. 7.-31. 7.	0.0	10.9	23.4	17.3	16.9	12.9	10.1	5.6	2.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		8.2	3.6	17.1	100.0
1. 8.-31. 8.	.8	6.9	16.1	18.1	19.4	12.9	11.3	6.9	4.4	2.8	0.0	.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0		9.3	4.2	22.5	100.0
1. 9.-30. 9.	.4	1.3	7.9	15.8	19.2	14.6	17.5	11.3	6.3	2.9	1.3	.8	.4	.4	0.0	0.0	0.0	0.0	0.0		11.1	4.3	27.1	100.0
1.10.-31.10.	0.0	3.0	6.7	14.2	25.4	11.9	15.7	6.0	4.5	3.0	3.7	4.5	1.5	0.0	0.0	0.0	0.0	0.0	0.0		11.4	5.1	24.2	54.0
1.11.-30.11.	1.2	0.0	4.9	17.1	18.3	13.4	12.2	9.8	9.8	2.4	6.1	3.7	0.0	1.2	0.0	0.0	0.0	0.0	0.0		12.2	5.2	26.3	34.2
1.12.-31.12.	.6	4.3	17.7	7.3	5.5	9.8	11.0	11.0	13.4	13.4	3.7	1.2	1.2	0.0	0.0	0.0	0.0	0.0	0.0		12.3	5.7	24.8	66.1

KEMI 1980 GUST SPEED

PERIOD	0	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38 MEAN	SD	MAX	% OBS
1. 1.-31. 1.	4.8	12.0	10.0	12.9	15.3	13.9	11.5	8.1	8.1	2.4	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	9.5	5.0	28.6	84.3
1. 2.-29. 2.	2.6	12.9	25.9	5.2	19.0	8.6	6.0	8.6	2.6	1.7	4.3	2.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.0	5.4	23.0	50.0
1. 3.-31. 3.	4.0	8.1	11.3	21.4	28.2	16.9	6.9	2.0	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.1	3.1	17.9	100.0
1. 4.-30. 4.	.4	9.6	24.2	24.2	23.8	10.8	6.3	.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.4	2.8	14.5	100.0
1. 5.-31. 5.	.4	10.9	21.0	31.0	21.0	10.9	2.8	1.2	.4	.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.3	2.8	19.6	100.0
1. 6.-30. 6.	.4	4.6	19.2	20.5	20.5	15.5	9.6	6.3	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.8	3.5	17.9	99.6
1. 7.-31. 7.	2.0	21.0	24.6	19.8	13.3	7.3	6.0	4.0	1.2	.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.0	3.7	18.6	100.0
1. 8.-31. 8.	1.2	8.9	14.9	19.0	17.3	11.7	8.1	7.7	6.5	2.0	2.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.4	4.6	21.8	100.0
1. 9.-30. 9.	.8	6.3	16.3	21.8	23.8	11.3	9.6	4.2	2.9	1.7	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.9	3.9	21.2	99.6
1.10.-31.10.	0.0	2.4	4.9	17.1	12.2	14.6	31.7	12.2	4.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.0	3.4	16.5	16.5
1.11.-30.11.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.12.-31.12.	25.8	10.6	15.2	10.6	13.6	3.0	7.6	4.5	1.5	3.0	1.5	0.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	7.2	5.9	25.1	26.6

KEMI 1981 GUST SPEED

PERIOD	0	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38 MEAN	SD	MAX	% OBS
1. 1.-31. 1.	5.9	2.2	7.6	11.9	15.1	10.3	8.6	8.1	13.5	7.0	4.3	1.6	2.2	.5	1.1	0.0	0.0	0.0	0.0	12.1	6.1	29.3	74.6
1. 2.-28. 2.	65.0	8.4	8.4	4.2	4.9	5.6	1.4	1.4	0.0	0.0	0.0	.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.1	4.0	22.6	63.8
1. 3.-31. 3.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.5	62.5	25.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	17.2	1.3	19.4	3.2
1. 4.-30. 4.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1. 5.-31. 5.	0.0	1.8	13.3	31.0	30.1	12.4	5.3	6.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.6	2.6	15.4	45.6
1. 6.-30. 6.	0.0	0.0	0.0	7.1	50.0	21.4	7.1	0.0	14.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.7	2.9	16.8	5.8
1. 7.-31. 7.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1. 8.-31. 8.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1. 9.-30. 9.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.10.-31.10.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.11.-30.11.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.12.-31.12.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

KEMI 1982 GUST SPEED

PERIOD	0	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38 MEAN	SD	MAX	% OBS
1. 1.-31. 1.	0.0	1.3	8.0	20.0	41.3	13.3	9.3	5.3	0.0	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.3	2.8	18.8	30.2
1. 2.-28. 2.	.8	13.6	10.2	10.2	11.0	22.0	13.6	5.9	4.2	5.9	.8	.8	.8	0.0	0.0	0.0	0.0	0.0	0.0	10.2	5.0	25.5	52.7
1. 3.-31. 3.	0.0	7.1	7.6	14.8	21.9	18.6	14.3	8.1	3.8	3.3	.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.0	3.9	20.3	84.7
1. 4.-30. 4.	0.0	2.9	10.9	25.1	21.8	10.9	13.0	7.9	4.2	.8	1.7	.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.8	3.9	22.5	99.6
1. 5.-31. 5.	0.0	1.6	12.6	15.8	27.1	15.8	14.2	7.7	4.9	.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.8	3.4	18.5	99.6
1. 6.-30. 6.	.4	7.5	19.2	27.5	17.5	9.6	5.4	7.5	3.3	.8	.4	.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.5	4.0	23.8	100.0
1. 7.-31. 7.	.4	5.2	15.7	23.0	18.1	19.4	8.5	7.7	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.9	3.4	17.4	100.0
1. 8.-31. 8.	0.0	2.8	17.4	22.2	24.3	11.8	11.8	7.6	1.4	.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.1	3.3	18.3	58.1
1. 9.-30. 9.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.10.-31.10.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.11.-30.11.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.12.-31.12.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

MARKET 1978 GUST SPEED

PERIOD	0	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	MEAN	SD	MAX	% OBS
1. 1.-31. 1.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1. 2.-28. 2.	0.0	2.0	3.1	16.3	14.3	17.3	16.3	10.2	5.1	4.1	5.1	4.1	1.0	1.0	0.0	0.0	0.0	0.0	0.0	12.4	5.1	26.4	43.8
1. 3.-31. 3.	0.0	2.4	13.4	13.8	11.7	12.6	11.7	16.6	7.7	5.3	2.0	2.0	.8	0.0	0.0	0.0	0.0	0.0	0.0	11.5	5.0	24.7	99.6
1. 4.-30. 4.	0.0	19.4	22.2	8.3	5.6	8.3	13.9	5.6	13.9	2.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.1	5.2	18.3	15.0
1. 5.-31. 5.	0.0	3.9	19.0	30.2	25.4	9.1	3.4	5.6	2.2	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.3	3.3	19.9	93.5
1. 6.-30. 6.	0.0	4.6	12.6	19.2	23.4	15.9	10.9	5.9	4.6	1.7	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.6	3.9	21.8	99.6
1. 7.-31. 7.	0.0	4.1	17.7	25.0	23.2	16.4	5.9	5.5	.9	.9	.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.6	3.3	21.1	88.7
1. 8.-31. 8.	0.0	5.2	5.2	11.0	17.5	24.0	11.0	9.7	13.6	2.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.1	4.0	19.4	62.1
1. 9.-30. 9.	0.0	3.4	8.5	18.6	14.8	14.0	7.6	6.8	5.9	3.8	3.0	8.9	3.0	1.3	0.0	.4	0.0	0.0	0.0	12.3	6.2	30.6	98.3
1.10.-31.10.	0.0	2.0	8.1	11.3	12.5	16.5	15.7	11.3	6.5	7.7	5.2	1.2	.4	1.6	0.0	0.0	0.0	0.0	0.0	12.3	5.1	27.8	100.0
1.11.-30.11.	0.0	0.0	3.0	8.1	10.2	11.1	14.0	15.3	16.2	11.9	3.4	2.6	1.3	1.7	.9	.4	0.0	0.0	0.0	14.4	5.0	30.4	97.9
1.12.-31.12.	0.0	1.3	8.5	11.9	21.6	19.9	13.1	15.3	5.5	2.1	.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.9	3.6	20.4	95.2

MARKET 1979 GUST SPEED

PERIOD	0	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	MEAN	SD	MAX	% OBS
1. 1.-31. 1.	0.0	4.3	14.9	15.7	10.2	14.0	11.5	8.5	13.2	3.4	2.1	1.3	.4	.4	0.0	0.0	0.0	0.0	0.0	10.9	5.0	26.8	94.8
1. 2.-28. 2.	1.1	8.9	11.7	13.3	16.7	17.2	13.9	9.4	6.1	.6	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.8	4.3	21.9	88.4
1. 3.-31. 3.	0.0	.4	2.0	6.9	18.0	17.1	15.1	11.0	12.2	9.8	5.7	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.2	4.3	23.4	98.8
1. 4.-30. 4.	.5	4.1	9.3	20.2	22.8	22.8	11.9	1.6	2.1	1.0	1.0	2.1	.5	0.0	0.0	0.0	0.0	0.0	0.0	9.7	4.0	24.3	88.4
1. 5.-31. 5.	0.0	.9	7.5	11.5	21.6	28.2	16.3	9.7	2.6	1.3	.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.6	3.2	21.2	91.5
1. 6.-30. 6.	0.0	4.2	14.3	23.8	27.5	17.5	5.8	3.7	1.6	.5	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.7	3.4	23.5	78.8
1. 7.-31. 7.	.6	15.2	18.5	26.4	17.4	11.2	6.7	2.8	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.5	3.3	17.4	71.8
1. 8.-31. 8.	0.0	3.6	10.5	19.8	26.7	15.8	10.1	6.5	5.3	.4	.4	.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.7	3.7	22.1	99.6
1. 9.-30. 9.	.4	2.5	5.4	15.4	14.2	18.8	17.1	9.2	5.0	6.3	1.7	2.1	1.3	.4	0.0	.4	0.0	0.0	0.0	11.8	4.9	30.6	100.0
1.10.-31.10.	.4	2.8	7.3	14.5	18.1	18.1	13.7	14.9	7.7	.8	.8	.4	0.0	0.0	0.0	.4	0.0	0.0	0.0	10.9	4.1	30.1	100.0
1.11.-30.11.	0.0	.4	1.3	10.7	16.4	16.9	16.0	16.9	9.3	5.8	1.3	1.8	.4	1.3	.4	.9	0.0	0.0	0.0	12.9	4.7	30.6	93.8
1.12.-31.12.	0.0	1.7	6.9	17.7	13.7	13.1	14.3	16.6	9.7	3.4	1.1	0.0	0.0	1.7	0.0	0.0	0.0	0.0	0.0	11.5	4.6	27.4	70.6

MARKET 1980 GUST SPEED

PERIOD	0	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	MEAN	SD	MAX	% OBS
1. 1.-31. 1.	0.0	.9	6.4	12.4	13.3	13.8	16.5	15.6	10.6	4.1	3.2	2.3	.9	0.0	0.0	0.0	0.0	0.0	0.0	12.3	4.6	25.1	87.9
1. 2.-29. 2.	6.5	7.8	21.2	16.5	10.0	19.5	13.9	3.0	1.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.0	4.0	17.0	99.6
1. 3.-31. 3.	0.0	1.6	8.9	20.2	26.3	17.8	13.0	2.0	4.0	2.4	1.2	1.6	.4	.4	0.0	0.0	0.0	0.0	0.0	10.2	4.1	27.0	99.6
1. 4.-30. 4.	1.3	12.0	15.0	29.2	9.4	15.0	8.6	4.7	1.7	1.7	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.4	4.1	21.3	97.1
1. 5.-31. 5.	.8	4.0	12.9	19.0	27.0	21.8	10.1	3.2	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.9	2.9	17.7	100.0
1. 6.-30. 6.	0.0	2.5	19.1	24.6	18.6	13.1	14.8	3.4	2.5	.8	.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.9	3.4	20.8	98.3
1. 7.-31. 7.	1.1	18.9	36.7	25.0	10.6	5.0	1.7	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.0	2.4	14.2	72.6
1. 8.-31. 8.	1.2	5.2	14.9	18.1	21.8	12.1	14.9	6.0	1.6	2.0	1.6	.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.4	4.0	22.9	100.0
1. 9.-30. 9.	0.0	5.0	15.0	20.8	19.6	16.7	15.4	7.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.0	3.3	15.9	100.0
1.10.-31.10.	.4	2.8	5.2	4.4	9.3	14.1	19.8	14.9	13.3	7.3	4.4	1.2	.8	1.2	.8	0.0	0.0	0.0	0.0	13.4	5.0	29.3	100.0
1.11.-30.11.	0.0	.8	4.6	10.4	15.4	15.8	15.0	11.3	10.0	7.1	6.7	1.3	.4	1.3	0.0	0.0	0.0	0.0	0.0	12.9	4.9	27.1	100.0
1.12.-31.12.	0.0	1.2	3.6	5.2	9.3	17.7	21.8	16.1	8.5	8.5	4.0	3.2	.4	.4	0.0	0.0	0.0	0.0	0.0	13.4	4.4	26.5	100.0

MÆRKET 1981 GUST SPEED

PERIOD	0	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38 MEAN	SD	MAX	% OBS
1. 1.-31. 1.	0.0	.4	2.1	6.8	9.3	21.5	20.7	14.8	8.0	8.9	5.5	.8	1.3	0.0	0.0	0.0	0.0	0.0	0.0	13.4	4.2	25.4	95.6
1. 2.-28. 2.	0.0	4.9	9.8	12.0	16.9	24.0	8.7	8.2	5.5	2.2	3.3	3.3	1.1	0.0	0.0	0.0	0.0	0.0	0.0	11.0	4.9	24.3	81.7
1. 3.-31. 3.	.4	3.2	12.6	18.2	21.1	15.8	10.1	5.3	4.5	3.6	2.4	2.0	.4	.4	0.0	0.0	0.0	0.0	0.0	10.4	4.8	26.0	99.6
1. 4.-30. 4.	0.0	3.3	12.9	18.8	20.8	13.8	11.7	7.1	4.2	2.5	2.1	.4	.4	1.3	0.0	.4	0.0	0.0	.4	10.4	5.1	36.0	100.0
1. 5.-31. 5.	0.0	3.3	20.7	23.7	26.1	18.3	1.7	2.9	1.7	1.2	.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.4	3.1	20.1	97.2
1. 6.-30. 6.	0.0	0.0	0.0	14.3	21.4	42.9	14.3	7.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.7	2.2	14.3	5.8
1. 7.-31. 7.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1. 8.-31. 8.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1. 9.-30. 9.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.10.-31.10.	0.0	4.0	11.1	15.2	18.2	22.2	8.1	5.1	4.0	2.0	4.0	3.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	11.0	5.4	28.8	39.9
1.11.-30.11.	0.0	2.1	2.1	7.1	13.4	10.5	10.0	11.7	14.6	9.6	7.1	5.0	4.2	.8	.4	.4	.8	0.0	0.0	14.8	5.8	33.4	99.6
1.12.-31.12.	0.0	1.3	3.3	7.5	7.9	15.8	15.0	16.3	15.0	7.5	5.8	4.2	.4	0.0	0.0	0.0	0.0	0.0	0.0	13.8	4.6	24.3	96.8

MÆRKET 1982 GUST SPEED

PERIOD	0	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38 MEAN	SD	MAX	% OBS
1. 1.-31. 1.	0.0	2.8	2.0	11.4	17.9	14.6	16.3	11.0	11.8	5.3	4.5	1.6	.8	0.0	0.0	0.0	0.0	0.0	0.0	12.4	4.6	24.6	99.2
1. 2.-28. 2.	.4	4.0	8.5	20.6	19.7	21.5	15.7	7.6	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.6	3.2	16.3	99.6
1. 3.-31. 3.	0.0	.4	7.7	17.3	22.2	19.4	13.7	8.9	4.8	4.0	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.7	3.8	21.0	100.0
1. 4.-30. 4.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1. 5.-31. 5.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1. 6.-30. 6.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1. 7.-31. 7.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1. 8.-31. 8.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1. 9.-30. 9.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.10.-31.10.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.11.-30.11.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.12.-31.12.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

KALBADAGRUND 1977 GUST SPEED

PERIOD	0	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38 MEAN	SD	MAX	% OBS
1. 1.-31. 1.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1. 2.-28. 2.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1. 3.-31. 3.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1. 4.-30. 4.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1. 5.-31. 5.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1. 6.-30. 6.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1. 7.-31. 7.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1. 8.-31. 8.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1. 9.-30. 9.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.10.-31.10.	0.0	1.0	6.6	9.7	17.3	15.8	24.0	8.7	8.7	2.0	3.1	1.5	1.0	.5	0.0	0.0	0.0	0.0	0.0	12.8	4.4	26.1	79.0
1.11.-30.11.	0.0	1.7	5.8	10.8	13.3	14.6	16.3	17.5	7.9	7.1	2.5	2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.4	4.4	23.4	100.0
1.12.-31.12.	0.0	.8	4.0	8.5	13.7	12.9	13.7	13.7	12.5	8.1	3.6	4.4	1.6	1.6	.4	.4	0.0	0.0	0.0	13.7	5.3	31.8	100.0

KALBADAGRUND 1978 GUST SPEED

PERIOD	0	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	MEAN	SD	MAX	% OBS
1. 1.-31. 1.	0.0	.4	7.7	12.1	13.7	15.3	10.5	14.1	10.5	8.5	5.2	1.2	.8	0.0	0.0	0.0	0.0	0.0	0.0		12.5	4.8	25.0	100.0
1. 2.-28. 2.	0.0	.4	6.3	21.0	24.6	14.7	13.4	4.0	8.9	6.3	.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		10.7	3.9	20.6	100.0
1. 3.-31. 3.	.8	4.8	8.9	16.1	21.0	20.2	8.9	8.9	3.6	4.4	.8	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0		10.2	4.3	23.7	100.0
1. 4.-30. 4.	1.7	9.2	15.4	20.8	16.7	14.6	6.3	2.9	6.3	2.1	2.9	.4	0.0	.8	0.0	0.0	0.0	0.0	0.0		9.2	4.8	26.8	100.0
1. 5.-31. 5.	0.0	6.5	11.7	14.9	24.6	20.2	11.3	4.0	4.0	2.4	.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		9.6	3.8	20.5	100.0
1. 6.-30. 6.	0.0	4.3	12.3	14.5	21.0	26.1	8.0	10.1	2.9	.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		9.6	3.5	18.3	57.5
1. 7.-31. 7.	0.0	17.9	36.6	16.4	11.2	8.2	8.2	.7	0.0	0.0	0.0	.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0		6.8	3.3	22.9	54.0
1. 8.-31. 8.	0.0	4.3	12.4	19.5	21.0	18.6	11.4	4.8	5.2	1.0	.5	1.0	.5	0.0	0.0	0.0	0.0	0.0	0.0		9.7	4.0	24.0	84.7
1. 9.-30. 9.	0.0	3.9	14.7	14.7	14.3	13.4	10.8	11.3	10.0	3.9	1.3	1.3	.4	0.0	0.0	0.0	0.0	0.0	0.0		10.9	4.8	25.1	96.3
1.10.-31.10.	0.0	0.0	4.4	9.2	14.8	13.1	20.1	17.5	12.7	5.2	1.3	1.3	.4	0.0	0.0	0.0	0.0	0.0	0.0		12.6	4.1	25.3	92.3
1.11.-30.11.	0.0	2.5	4.1	6.6	18.0	9.0	12.3	13.1	14.8	9.8	5.7	4.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0		13.4	4.9	22.9	50.8
1.12.-31.12.	0.0	2.9	7.4	18.9	18.1	11.1	12.8	14.0	6.2	5.3	2.5	.4	0.0	.4	0.0	0.0	0.0	0.0	0.0		11.1	4.5	26.3	98.0

KALBADAGRUND 1979 GUST SPEED

PERIOD	0	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	MEAN	SD	MAX	% OBS
1. 1.-31. 1.	0.0	4.4	8.1	14.9	14.5	11.3	11.7	10.9	6.9	6.5	3.6	3.6	2.8	.8	0.0	0.0	0.0	0.0	0.0		12.1	5.7	26.3	100.0
1. 2.-28. 2.	.4	7.2	14.3	11.7	17.9	18.4	15.7	8.5	4.0	.9	.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		9.7	3.9	21.3	99.6
1. 3.-31. 3.	0.0	0.0	3.2	13.3	24.2	18.1	17.3	8.9	5.2	5.6	2.4	.8	.8	0.0	0.0	0.0	0.0	0.0	0.0		11.6	4.0	25.6	100.0
1. 4.-30. 4.	.8	6.7	14.6	22.6	21.3	14.6	7.5	5.0	2.9	2.1	.4	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0		9.1	4.1	23.5	99.6
1. 5.-31. 5.	0.0	2.4	4.4	12.1	19.8	25.0	19.4	10.9	3.6	1.6	.4	.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0		10.9	3.3	23.1	100.0
1. 6.-30. 6.	0.0	1.7	7.3	20.2	21.5	18.5	17.6	6.9	3.0	2.1	.4	0.0	.4	.4	0.0	0.0	0.0	0.0	0.0		10.3	3.7	26.3	97.1
1. 7.-31. 7.	1.4	7.2	24.9	25.3	19.9	10.0	4.5	3.6	2.7	.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		7.8	3.4	18.1	89.1
1. 8.-31. 8.	.4	7.5	12.9	19.1	17.0	15.8	16.2	6.6	2.1	1.2	.4	.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0		9.4	3.9	22.5	97.2
1. 9.-30. 9.	0.0	6.3	11.3	6.7	11.3	14.2	14.6	12.9	7.5	6.7	1.7	2.5	2.5	.8	1.3	0.0	0.0	0.0	0.0		12.3	5.8	28.3	100.0
1.10.-31.10.	0.0	2.0	5.6	12.5	13.3	16.5	19.0	16.1	8.9	4.4	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		11.7	4.0	21.9	100.0
1.11.-30.11.	0.0	1.7	4.2	10.0	11.7	17.1	16.3	11.7	11.3	6.3	6.3	2.1	1.7	0.0	0.0	0.0	0.0	0.0	0.0		13.0	4.8	25.1	100.0
1.12.-31.12.	0.0	1.2	10.1	12.9	12.5	14.5	12.9	14.1	11.3	6.0	1.2	.4	2.0	.4	.4	0.0	0.0	0.0	0.0		12.1	4.9	28.3	100.0

KALBADAGRUND 1980 GUST SPEED

PERIOD	0	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	MEAN	SD	MAX	% OBS
1. 1.-31. 1.	0.0	1.6	12.6	18.2	17.4	12.6	10.9	12.1	6.5	5.7	1.6	.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0		10.8	4.4	22.3	99.6
1. 2.-29. 2.	1.0	3.8	23.8	22.9	16.7	9.5	7.6	11.9	1.4	1.0	.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		8.7	3.8	21.8	90.5
1. 3.-31. 3.	1.6	10.9	17.0	19.0	20.6	20.2	9.3	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		8.8	3.1	15.6	99.6
1. 4.-30. 4.	2.1	7.9	15.9	20.9	21.3	18.4	7.5	4.6	.8	.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		8.3	3.3	18.6	99.6
1. 5.-31. 5.	0.0	2.8	15.4	18.2	26.7	19.4	10.5	4.0	1.6	.8	.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		9.1	3.2	20.1	99.6
1. 6.-30. 6.	0.0	5.8	17.5	18.8	18.3	13.3	10.8	6.7	6.3	1.3	.4	.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0		9.5	4.2	22.1	100.0
1. 7.-31. 7.	1.2	11.7	27.0	25.4	11.3	10.1	4.8	2.4	2.4	1.2	.8	1.2	0.0	.4	0.0	0.0	0.0	0.0	0.0		7.8	4.3	27.4	100.0
1. 8.-31. 8.	0.0	7.7	16.9	19.4	17.7	17.7	12.5	6.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		8.7	3.5	17.9	100.0
1. 9.-30. 9.	0.0	11.7	17.5	17.5	21.7	12.9	8.8	5.0	4.2	.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		8.5	3.8	19.2	100.0
1.10.-31.10.	0.0	.4	.8	6.0	16.5	19.4	14.9	22.6	10.5	3.2	2.4	.8	1.6	.8	0.0	0.0	0.0	0.0	0.0		13.1	4.0	26.3	100.0
1.11.-30.11.	0.0	1.3	2.9	10.4	16.3	17.5	11.7	11.3	15.8	3.8	5.8	2.1	0.0	.8	.4	0.0	0.0	0.0	0.0		12.9	4.8	28.3	100.0
1.12.-31.12.	0.0	.4	3.2	11.3	16.9	20.2	14.1	11.3	8.1	7.7	5.2	.8	.8	0.0	0.0	0.0	0.0	0.0	0.0		12.5	4.4	24.7	100.0

KALBADAGRUND 1981 GUST SPEED

PERIOD	0	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36 38	MEAN	SD	MAX	% OBS
1. 1.-31. 1.	0.0	.8	4.0	10.1	9.7	15.4	10.1	17.0	13.8	7.7	6.9	3.6	.8	0.0	0.0	0.0	0.0	0.0	0.0	13.6	4.9	25.0	99.6
1. 2.-28. 2.	0.0	3.6	10.7	18.8	21.0	12.9	9.4	9.4	6.3	4.0	2.2	1.3	.4	0.0	0.0	0.0	0.0	0.0	0.0	10.6	4.6	25.4	100.0
1. 3.-31. 3.	0.0	5.2	16.9	18.5	15.3	16.1	9.3	6.9	4.0	3.2	4.0	.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.9	4.6	23.4	100.0
1. 4.-30. 4.	.4	2.5	9.6	17.1	20.8	19.2	15.8	7.9	5.0	1.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.1	3.6	19.5	100.0
1. 5.-31. 5.	.4	3.7	16.5	21.8	23.0	16.9	11.9	4.1	1.2	.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.8	3.2	18.3	98.0
1. 6.-30. 6.	0.0	0.0	21.4	14.3	14.3	7.1	42.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.8	3.3	13.7	5.8
1. 7.-31. 7.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1. 8.-31. 8.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1. 9.-30. 9.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.10.-31.10.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.11.-30.11.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.12.-31.12.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

KALBADAGRUND 1982 GUST SPEED

PERIOD	0	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36 38	MEAN	SD	MAX	% OBS
1. 1.-31. 1.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1. 2.-28. 2.	0.0	0.0	0.0	30.2	23.3	9.3	4.7	9.3	9.3	9.3	2.3	2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.6	4.5	22.1	19.2
1. 3.-31. 3.	1.3	4.3	7.3	28.9	19.7	20.1	14.1	6.4	5.1	.4	.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.8	3.6	20.4	94.4
1. 4.-30. 4.	0.0	2.9	16.3	16.7	17.1	18.3	12.9	9.6	4.6	1.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.8	3.7	19.4	100.0
1. 5.-31. 5.	0.0	2.8	10.5	17.3	11.7	16.9	23.4	12.5	4.4	.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.5	3.6	18.9	100.0
1. 6.-30. 6.	0.0	1.3	19.1	22.0	14.4	11.0	10.2	7.6	5.9	4.2	1.3	1.7	.8	.4	0.0	0.0	0.0	0.0	0.0	10.3	4.9	26.6	98.3
1. 7.-31. 7.	0.0	5.7	16.7	27.3	23.7	18.4	5.3	2.0	.4	.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.2	2.8	18.2	98.8
1. 8.-31. 8.	.4	3.7	15.9	16.7	19.1	19.1	10.2	8.1	4.5	.8	.8	.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.7	3.9	23.4	99.2
1. 9.-30. 9.	0.0	6.0	11.5	21.3	14.5	12.3	13.2	11.1	7.2	2.6	.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.0	4.2	21.3	97.9
1.10.-31.10.	0.0	2.4	7.7	14.6	12.1	16.6	19.4	12.1	8.1	2.4	2.8	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.4	4.3	22.8	99.6
1.11.-30.11.	0.0	.8	3.2	4.0	5.6	12.9	13.7	19.4	20.2	6.5	5.6	5.6	2.4	0.0	0.0	0.0	0.0	0.0	0.0	14.8	4.6	25.0	51.7
1.12.-31.12.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

ULKOKALLA 1978 GUST SPEED

PERIOD	0	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36 38	MEAN	SD	MAX	% OBS
1. 1.-31. 1.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1. 2.-28. 2.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1. 3.-31. 3.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1. 4.-30. 4.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1. 5.-31. 5.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1. 6.-30. 6.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1. 7.-31. 7.	2.3	11.7	35.9	18.0	14.1	10.9	5.5	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.8	3.1	15.1	51.6
1. 8.-31. 8.	.5	7.8	25.7	28.6	17.0	15.5	2.9	1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.3	2.7	15.5	83.1
1. 9.-30. 9.	.4	8.0	16.9	20.4	23.1	13.3	6.7	4.0	3.1	2.7	0.0	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.8	4.1	23.0	93.8
1.10.-31.10.	0.0	.8	4.1	7.4	8.6	15.6	13.2	14.4	17.7	7.0	5.8	3.7	1.2	.4	0.0	0.0	0.0	0.0	0.0	14.0	4.8	26.0	98.0
1.11.-30.11.	0.0	1.5	3.0	4.0	13.0	12.5	15.5	13.5	18.5	9.0	3.5	1.0	1.5	1.5	1.0	1.0	0.0	0.0	0.0	14.2	5.1	31.6	83.3
1.12.-31.12.	0.0	0.0	11.6	18.6	23.3	27.9	9.3	7.0	2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.8	2.9	17.2	17.3

ULKOKALLA 1980 GUST SPEED

PERIOD	0	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	MEAN	SD	MAX	% OBS
1. 1.-31. 1.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1. 2.-29. 2.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1. 3.-31. 3.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1. 4.-30. 4.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1. 5.-31. 5.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1. 6.-30. 6.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1. 7.-31. 7.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1. 8.-31. 8.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1. 9.-30. 9.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.10.-31.10.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.11.-30.11.	0.0	3.8	12.3	6.6	13.2	6.6	18.9	15.1	9.4	9.4	2.8	1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.3	4.9	23.7	44.2
1.12.-31.12.	0.0	2.2	6.5	13.4	19.9	9.7	17.2	13.4	8.6	2.7	2.7	1.1	1.6	1.1	0.0	0.0	0.0	0.0	0.0	0.0	11.9	4.8	26.8	75.0

ULKOKALLA 1981 GUST SPEED

PERIOD	0	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	MEAN	SD	MAX	% OBS
1. 1.-31. 1.	0.0	0.0	13.9	18.1	23.6	6.9	8.3	4.2	2.8	8.3	2.8	6.9	1.4	1.4	1.4	0.0	0.0	0.0	0.0	0.0	11.9	6.2	28.4	29.0
1. 2.-28. 2.	12.3	30.7	12.3	8.4	16.2	9.5	2.8	1.7	2.2	1.7	.6	1.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.4	5.0	23.0	79.9
1. 3.-31. 3.	4.3	7.4	16.5	27.3	13.9	9.1	9.1	4.8	3.0	1.7	1.7	.4	.4	0.0	.4	0.0	0.0	0.0	0.0	0.0	8.6	4.7	29.8	93.1
1. 4.-30. 4.	.5	5.4	24.8	21.8	11.4	9.9	8.4	5.9	5.4	4.5	1.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	9.2	4.8	26.4	84.2
1. 5.-31. 5.	0.0	2.6	23.1	35.9	21.8	9.0	5.1	1.3	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.8	2.7	17.9	31.5
1. 6.-30. 6.	0.0	0.0	0.0	14.3	28.6	21.4	35.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.3	2.4	13.9	5.8
1. 7.-31. 7.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1. 8.-31. 8.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1. 9.-30. 9.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.10.-31.10.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.11.-30.11.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.12.-31.12.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

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